Materials Engineering in Product Design & Manufacture

Materials & Methods

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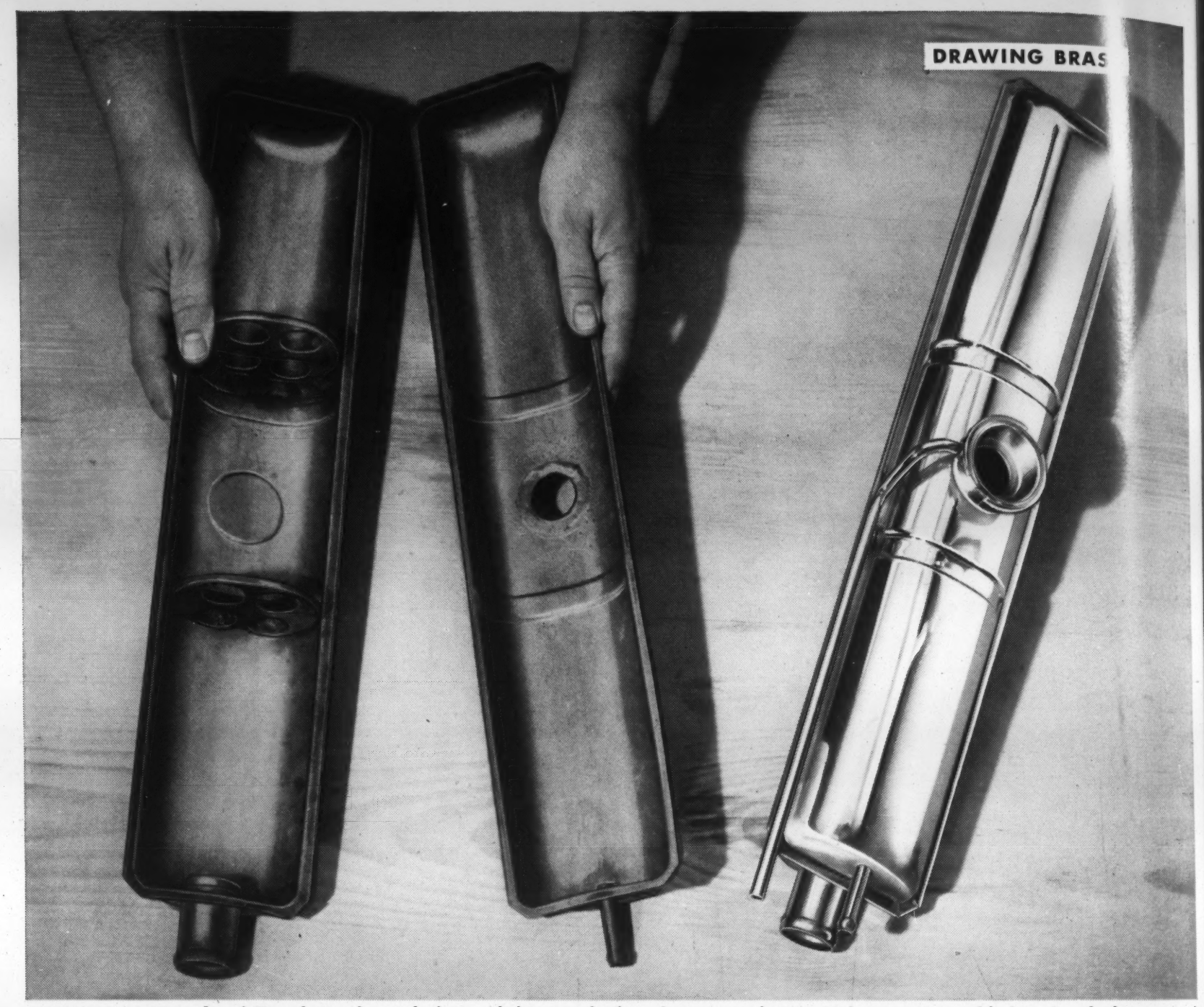
Age-Hardenable Metals—M & M Manual No. 109 page **121**
Metal Show Preview page 13
'Machining' Aluminum by Etching page 89
New Super-High Strength Steels page 100
Pressed and Sintered Glass Powder Shapes page 94
Filled Teflon for Dry Bearings page 112
Ceramic-Coated Metals page 104
Complete Contents page 1

PRICE FIFTY CENTS



RADIATOR TANK made of Formbrite shown before polishing and after chromium plating. Halves are assembled with a lock seam and soldered together with baffles inside. Intake spout, overflow tube and connecting fitting are also attached.

New fine-grain drawing brass cuts rejects from 13% to under 1%

These radiator tanks—used in a leading sports car—were first made of ordinary drawing brass.

But Morrison Steel Products Company, Buffalo, N. Y., found this brass wasn't stiff enough after forming. During handling, polishing and plating, many dents and nicks appeared on the surface. Rejects ran at about 13%.

Then Morrison turned to Formbrite* — Anaconda's new fine-grain drawing brass. Here's what happened.

1. Rejects dropped to less than 1%.
2. Appearance of the final plated tank (very important in a sports car) was so much improved that now Formbrite is specified for all these tanks.
3. Polishing costs were sliced almost in half.

WHY MORRISON FOUND FORMBRITE BETTER, CHEAPER TO USE

Formbrite has a superfine grain. Produced by special methods of rolling and annealing, this grain is *so fine* that often a simple color buff brings it to a bright, lustrous finish. (Compare magnification of Formbrite Drawing Brass with that of ordinary drawing brass. At right.)

Formbrite is harder, stiffer, springier and more scratch-resistant. It resists denting and deforming. Yet Formbrite is surprisingly ductile . . . readily stamped, formed, drawn and embossed. And Formbrite plates beautifully.

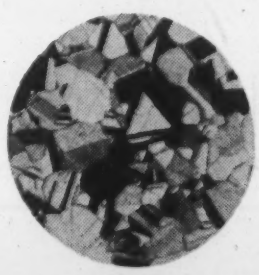
NO EXTRA COST

Premium price for this premium metal? Not at all. Formbrite costs not a penny more than ordinary drawing brass. It comes in sheets, strips and coils—in all commercial widths and gages.

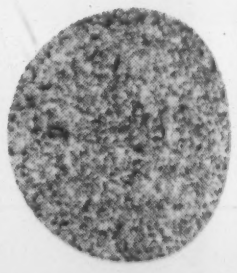
FREE SAMPLE

The way to find out about Formbrite is to try it yourself. Ask for a sample and more information. Just write to: *The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*Reg. U. S. Pat. Off. 5487



75x magnification of ordinary drawing brass.



75x magnification of superfine-grain Formbrite.

Formbrite

FINE-GRAIN DRAWING BRASS
an ANACONDA® product

Made by
THE AMERICAN BRASS COMPANY

For more information, turn to Reader Service Card, Circle No. 318

Materials Engineering in Product Design & Manufacture

Materials & Methods®

OCTOBER 1954 **VOL. 40, NO. 4**

METAL SHOW PREVIEW 13
Correlated technical program. List of exhibitors

FEATURE ARTICLES

'Machining' Aluminum by Etching ..... *M. C. Sanz* 89
May replace expensive skin milling. Also looks promising for steel and titanium

Pressed and Sintered Glass Powder Shapes ..... *W. H. McKnight* 94
New technique makes possible parts with intricate design and high properties

Copper Alloy Bearings ..... *J. B. Mohler* 97
Bronze, copper-lead, and leaded bronze meet wide range of service requirements

New Super-High Strength Structural Steels ..... *A. E. Nehrenberg* 100
Can be heat treated to strength levels of 200,000 to 300,000 psi

Properties of Ceramic-Coated Metals ..... *B. W. King* 104
Applications show where ceramic coatings can be used to advantage

Chromium-Nickel Alloy Steel Powders ..... *E. Gordon, W. V. Knopp, J. D. Shaw* 107
Iron powders plus small alloy powder additions produce better properties

Zinc Die-Cast Threaded Fasteners ..... *E. W. Horvick* 110
Provide design advantages and are less costly than some other types

Filled Teflon for Dry Bearings ..... *S. Ricklin and R. R. Miller* 112
Four new compositions provide improved service under severe conditions

Materials at Work 115
New and old materials in unusual applications

A Low Cost Injection Molding Material ..... *Kenneth Rose* 144
Asbestos fibers bonded wtih asphalt or resins find use where high strength is not needed

ENGINEERING FILE FACTS

Lead and Lead Alloys 139
Relative Strengths and Densities of Some Engineering Materials 143

MATERIALS & METHODS MANUAL NO. 109

Age-Hardenable Metals ..... *J. L. Everhart* 121

DEPARTMENTS

The Materials Outlook 3
Materials Briefs 7
Men of Materials 9
Materials Engineering News 11
Reader Service 71
Manufacturers' Literature 72
One Point of View 87
New Materials, Parts, Finishes 149
Contents Noted 179
News of Engineers, Companies, Societies 214
Meetings & Expositions 233
Advertisers and Their Agencies 286
Last Word 288

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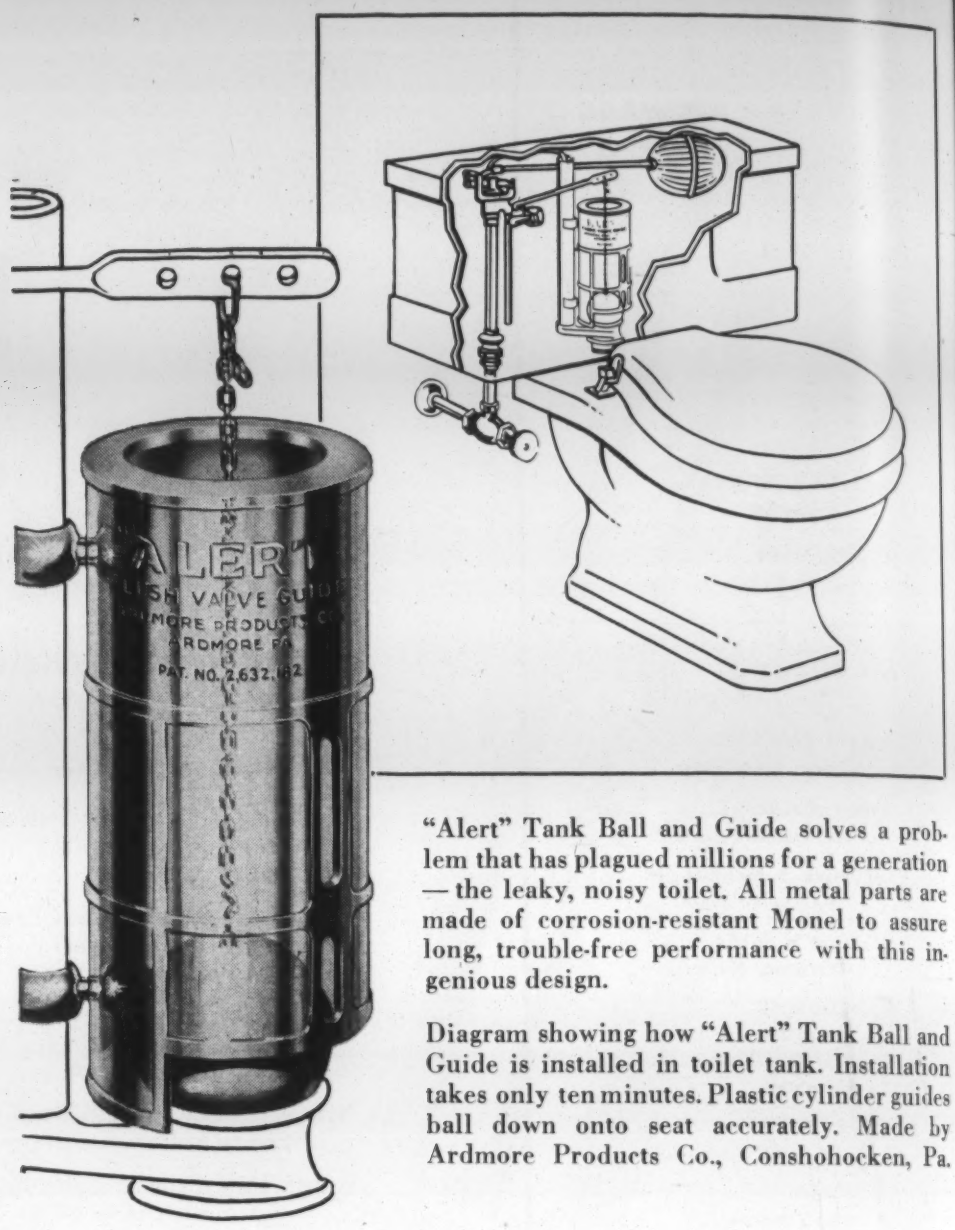
Design Ingenuity Stops Bathroom Jiggling



"Alert" Tank Ball and Guide solves a problem that has plagued millions for a generation — the leaky, noisy toilet. All metal parts are made of corrosion-resistant Monel to assure long, trouble-free performance with this ingenious design.

Diagram showing how "Alert" Tank Ball and Guide is installed in toilet tank. Installation takes only ten minutes. Plastic cylinder guides ball down onto seat accurately. Made by Ardmore Products Co., Conshohocken, Pa.

Probably every household is bothered at times by a "runny" toilet tank.

Once let the conventional arrangement of wires, guides and ball-spindle get just a trifle out of adjustment, and the water gurgles and splashes until someone jiggles the handle. Or else takes off the tank cover and re-seats the ball by hand.

A designer of surgical appliances had his rest disturbed by a noisy toilet tank just once too often. So he tore out the tangly wires, did away with the shifty wire guides, and substituted a hollow plastic tube and a round rubber ball suspended on a non-kinking chain.

But he didn't stop there. He realized there were several spots where even this simple device *could* fail or get out of kilter. One was the hook, chain and insert in the ball to which the chain is fastened. He foresaw how corrosive attack or wear might cause them to weaken and break.

The other two spots were the two riveted clamps with their spring grips that hold the plastic tube firmly in alignment. If they weakened or lost their spring properties, the tube could become dislodged.

To guard against failure in those three spots, he specified strong, corrosion-resistant Monel.

The device worked so beautifully he decided to make it commercially. The result is the famous "Alert" Tank Ball and Guide described in newspapers and popular magazines.

Perhaps the experience of this designer reminds you of some application in which metal failure has been bothering you. If so, Monel or one of the other Inco Nickel Alloys may prove a ready solution to your problem.

A concise description of the useful properties and characteristics of these alloys is included in a handy booklet, "Standard Alloys for Special Problems." A copy is yours for the asking.

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67 Wall Street, New York 5, N. Y.

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MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL • "S"® MONEL
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CHICAGO: October 30-November 5

1954 Metal Show

36th National Metal Congress and Exposition

CO-SPONSORS:

- **American Society for Metals**
- **American Welding Society**
- **Institute of Metals Division of the AIME**
- **Society for Nondestructive Testing**
- **Metals Division of the Special Libraries Association**

The 1954 Metal Show—the 36th National Metal Congress and Exposition—will take place October 30 through November 5 in Chicago, which has been host city for nine previous Metal Shows and was the scene of the first National Metal Exposition in 1919.

The National Metal Congress, at which members of participating societies will hear technical papers and discussions, will be held in the headquarters hotels of the individual societies. The National Metal Exposition will fill the vast International Amphitheatre in Chicago's famed stockyards district.

Participating Societies

The founder-sponsor of the Metal Show is the American Society for Metals, which is credited with building the show into one of the major engineering and manufacturing gatherings extant. Three other major technical societies directly concerned with the advancement of science and engineering in the metals industry co-sponsor the metals show. They are: the American Welding Society, the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, and the Society for Nondestructive Testing. In addition to the meetings of the sponsoring societies, the Metals Division of the Special Libraries Association will hold meetings and field trips, and the Industrial Heating Equipment Association will hold special sessions on furnace atmospheres and induction heating.

Meeting Places

The American Society for Metals will hold its technical sessions and business meetings in the Palmer House, the Institute of Metals Division of the AIME and the Society for Nondestructive Testing will meet in the Hotel Morrison, and the American Welding Society will meet in the Hotel Sherman. The Special Libraries Association will hold its technical sessions in the Conrad Hilton Hotel.

Exposition

The 1954 National Metal Exposition will be the largest of the nine held in Chicago. Opening on Monday, Nov. 1, the International Amphitheater's six acres of display

(Continued on page 254)

These full-length dome cars are part of an order for 121 being built by The Budd Company for the Santa Fe Railway. They feature not only unexcelled facilities for passenger enjoyment . . . but also the *safety and economy* of Crucible Rezistal® stainless steel.

Because they're *all stainless* — their strength-weight ratio is higher than you'd find in low alloy carbon steel. The cars are *lighter yet stronger* than ordinary steel cars, which means the Santa Fe will be able to haul as many as 25 of these cars with the same drawbar pull they'd need for 20 low alloy carbon steel cars.

What's more, the passive surface of Crucible stainless will never need painting . . . never need more than a "once-over-lightly" by maintenance crews to keep its sparkling new look. And, beneath the skin, where corrosion and vibration can undermine the strength of vital structural members — the high corrosion resistance and fatigue strength of Crucible stainless will keep these cars in service for a lifetime.

Budd would not have chosen stainless for all the cars they build unless it was a *practical shop metal.* And it is. For it can be formed, machined, welded, drawn, heat-treated — processed in any way you'd normally use for ordinary steel.

So don't forget the Crucible family of stainless steels where you need corrosion resistance . . . high fatigue, creep and structural strength . . . resistance to wear and temperature extremes . . . workability. We'll be glad to help you select the best stainless grade for your job. Let our Metallurgical Engineering Department make practical suggestions.

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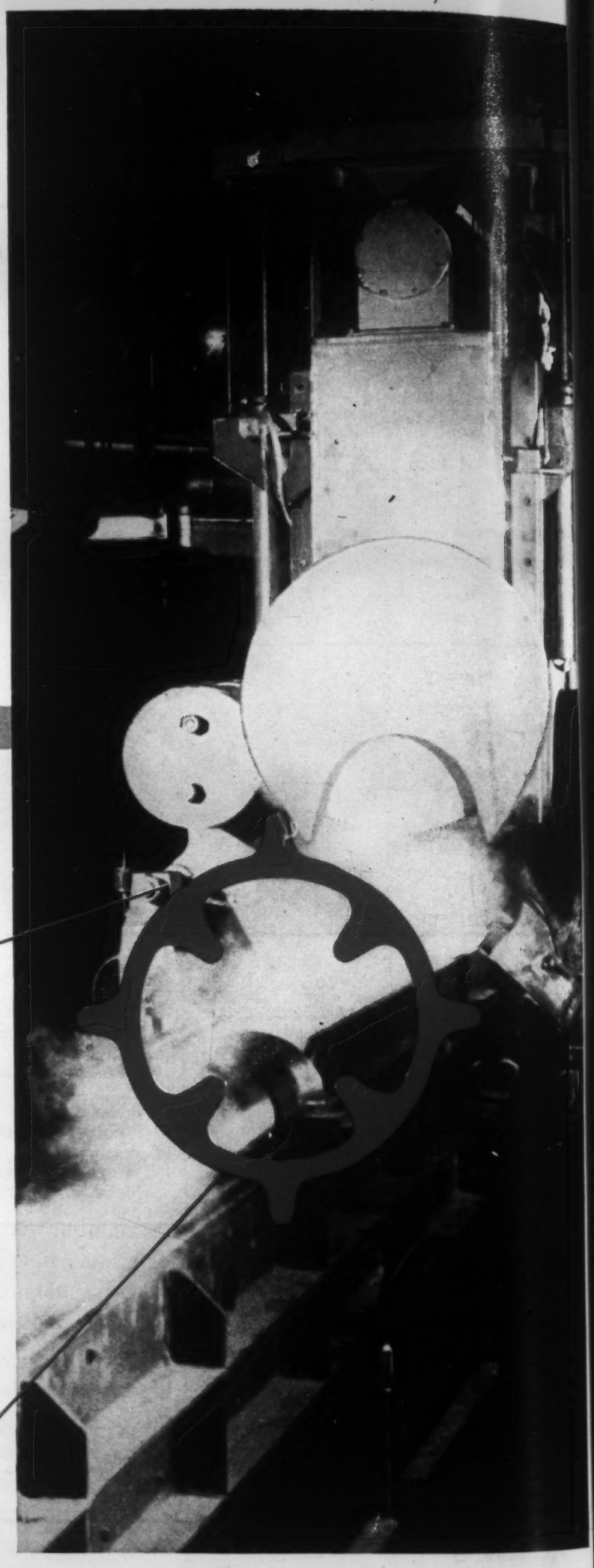
CONDENSED PROGRAM OF TECHNICAL SESSIONS

36th National Metal Congress, Chicago, Oct. 30 — Nov. 5, 1954

	AMERICAN SOCIETY FOR METALS Palmer House	AMERICAN WELDING SOCIETY Sherman Hotel	INSTITUTE OF METALS, AIME Morrison Hotel	SOCIETY FOR NONDESTRUCTIVE TESTING Morrison Hotel
Mon., Nov. 1				
Morning	Constitutional Diagrams of Various Ferrous and Nonferrous Alloy Systems (5 papers)	Prize Awards Adams Lecture	Deformation (6 papers) Constitution (5 papers)	Educational Program
Afternoon	Mechanical Metallurgy (4 papers) Processing (3 papers)	1. Resistance Welding 2. Weldability	Diffusion (7 papers) Powder Met. and Oxidation (4 papers)	Educational Program
Evening		President's Reception, Annual Dinner	Metal Science (8:00 p.m.) (4 speakers)	
Tues., Nov. 2				
Morning	Hardenability (4 papers)	3. Weldability 4. Resistance Welding 5. Shielded Arc Welding	General Session (8 papers) Titanium Symposium (5 papers)	Radiography (4 papers)
Afternoon	Physical Metallurgy (4 papers)	Section Officers Meeting 6. Weldability 7. Surfacing	Phase Transformation and Recrystallization Titanium Symposium, Panel Discussion Nuclear Metallurgy Committee (4:00 p.m.)	International Program Eddy Current Applications and NDT Developments Abroad
Wed., Nov. 3				
Morning	Annual Meeting, Campbell Memorial Lecture	8. Aircraft and Rocketry 9. Titanium, Zirconium, Molybdenum 10. Inert Arc Welding	Creep (5 papers)	Ultrasonics (4 papers)
Afternoon	Ferrous Physical Metallurgy (3 papers) Mechanical Properties (4 papers)	11. Pressure Vessels and Piping 12. Brazing 13. Symposium: Fused Metal, Coatings	Titanium (8 papers) End of AIME Program	Mehl Honor Lecture, Awards, 14th Annual Business Meeting
Thurs., Nov. 4			**METALS DIVISION SPEC. LIBRARIES ASSOC.** **Conrad Hilton Hotel**	
Morning	Stainless Steels (4 papers) Heat Treatment (4 papers)	14. Aircraft 15. Design and Production 16. Cutting	The Small Metallurgical Library	NDT Applications in Transportation and Oil Industries
Afternoon	High Temperature Properties (4 papers)		Economics and Marketing in Metallurgical Fields	Fluorescent Penetrant and Magnetic Particle Inspection Symposium: "Setting Acceptance Standards"
Fri., Nov. 5				
Morning		17. High Temp. Materials 18. Structural 19. Applications	Field trip to Inland Steel	
Afternoon		Note: Each session listed includes several papers. AWS holds up to 3 simultaneous sessions each morning and afternoon	Field trip to Research Library, Purdue Extension Building, Hammond, Indiana	

let us take a closer look at your

"difficult to solve" problems involving tubing and solids of special alloys and cross-sections



Two years of experimental production and several thousand tons of finished extruded products have given B&W a background that can be put to work for you in solving problems involving tubing and solids of special alloys and cross-sections. Through extrusion at B&W:

1. **New alloys have become commercially available as seamless tubing.** These include certain proprietary alloys and various types of ferrous alloys which have been known previously as non-pierceable materials.
2. **Tubing having certain special shaped cross-sections has been produced commercially.** This includes tubing having inside and outside shapes which are independent of each other, such as circular OD-finned ID, used to solve special heat transfer problems.
3. **Solids having special shaped cross-sections have been produced.** These include shapes difficult or impossible to produce as rolled sections.

Through extrusion, Mr. Tubes, your local B&W Tubing Representative, has helped others to solve problems involving tubing and solids of special materials and cross-sections. Call on him if you have such problems; chances are he will be able to help you.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-4032(X)

For more information, turn to Reader Service Card, Circle No. 327

LIST OF EXHIBITORS

36th National Metal Congress and Exposition, Chicago, Oct. 30-Nov. 5, 1954

Exhibitor	Booth Number
A B C Die Casting Mach. Co.	2030
A. I. T. Diamond Tool Co.	1658
Ace Drill Brushing Co., Inc.	2255
Acetogen Gas Co.	2147
Acme Mfg. Co.	1640
Acme Steel Co.	2129
Acme Tool Co.	1005
Action Diamond Tool Co.	1135
Adamas Carbide Corp.	1411
Air Reduction Sales Co.	341
Ajax Electrothermic Corp.	752
Ajax Engineering Corp.	752
Ajem Laboratories, Inc.	1145
Centri-Spray Corp.	1745
Ajax Electric Co., Inc.	752
Adjusto Equip. Co.	1057
Aldridge Industrial Oils, Inc.	1424
Al-Fin Div. Fairchild Engine & Airplane Corp.	2070
Allegheny Ludlum Steel Corp.	336
Allis-Chalmers Mfg. Co.	242
Allison Co.	142
Alloy Engineering & Casting Co.	1101
Alloy Metal Wire Co. Div. of H. K. Porter Co., Inc.	1645
Alpha Metals, Inc.	2344
American Brake Shoe Co.	762
American Cast Iron Pipe Co.	1020
American Chain & Cable Co.	
American Chemical Paint Co.	1036
American Cyanamid Co.	132
American Cystoscope Makers, Inc.	2323
American Gas Association	843, 854
American Gas Furnace Co.	8430-H
American Machine & Metals, Inc.	1248
American Manganese Steel Div.	762
American Marietta Co.	1618
American Metal Market	1549
American Nickeloid Co.	2314
American Optical Co.	2229
American Pullmax Co., Inc.	1253
American Society for Metals	603
American Wheelabrator & Equipment Corp.	632
Chrysler Corp., Amplex Div.	1335
Applied Research Labs.	1342
Arcair Co.	1445
Aronson Machine Co.	2354
Arwood Precision Casting Corp.	1254
Ashworth Bros., Inc., Metals Div.	1723
Atlas Press Co.	2057
Atomic Energy of Canada Ltd., Comm. Prod. Co.	2040
Automotive Industries Magazine	2155
Higbie Mfg. Co., Avon Tube Div.	1939
The Babcock & Wilcox Co.	236
Baird Associates, Inc.,	1348
Baker & Co., Inc.	1327
Bakelite Div., Union Carbide & Carbon	653
Baldwin-Lima-Hamilton	1065
Balteau Electric Corp.	2246
Banner Mfg. Co.	1019
Baron Industries	2364
Bausch & Lomb Optical Co.	1242
Morris Bean & Co.	2118
Bell & Gossett Co.	441
The Beryllium Corp.	1717
Binks Mfg. Co.	420
Black Drill Co.	1511
G. S. Blakeslee & Co.	1016
Boice-Crane Co.	1729
Brainard Steel Div.	1758
Brake Shoe & Casting Div.	762
Branson Instruments, Inc.	2244
Bridgeport Brass Co.	1015
Bristol Co.	1441
Charles Bruning Co., Inc.	1128
Brush Beryllium Co.	2348
Brush Electronics Co.	2317
Brush Laboratories Co.	2317
Buck Tool Co.	460
Buehler, Ltd.	1239
The Cambridge Wire Cloth Co.	1646
Can-Lok Division Empire Products, Inc.	1056
Campbell Machine Div.	1228
Carbide & Carbon Chem. Co.	653
Carboloy Dept.	1540
Casting Engineers, Inc.	1746
The Challenge Machinery Co.	2130
Chase Brass & Copper Co.	
Chicago Rivet & Machine Co.	1623
The Chicago Screw Co.	2223
Chicago Tool & Engineering Co.	2253
Chilton Co.	2155
Chrysler Corp.	1335
Cincinnati Sub Zero Products Co.	
Circo Equipment Co.	225
Cities Service Oil Co.	1216
Clementina, Ltd.	1002
Clevite Corp.	2317
Climax Molybdenum Co.	148
Cold Metal Products	
Mr. Frank J. O'Laughlin, Commander Mfg. Co.	1309
Commercial Filters Corp.	1530
Consolidated Industries, Inc.	1524
Consolidated Vacuum Corp.	2156
Continental Industrial Engineers, Inc.	843-G
Cooley Electric Mfg. Corp.	1649
Crane Packing Co.	136
Dake Engine Co.	1749
Dean Products, Inc.	1401
Delaware Tool Steel Corp.	2322
Deits Power Tool Div.	1053
Machinery Div., A. P. DeSanno & Son, Inc.	2139
Dir. of Tech. Publ., Detrex Corp.	1365
Detroit Testing Machine Co.	1148
Diamond Machine Tool Co.	1260
Diamond Power Specialty Corp.	2140
Die Casting	1055
Ding's Magnetic Seperator Co.	1316
The Diversey Corp.	1718
Doehler-Jarvis Corp.	260
The Dow Chemical Co.	620
Dow Furnace Co.	1041
Dreis & Krump Mfg. Co.	458
Wilbur B. Driver Co.	2029
Driver-Harris Co.	2267
Dunmore Co.	1407
E. I. DuPont de Nemours & Co., Inc.	2050
E. Shore Machine Products Co.	1448
Eclipse Fuel Engineering Co.	854-D
Elastic Stop Nut Corp. of America	2023
Electric Arc, Inc.,	2102
The Electric Furnace Co.	636
Electro-Alloys Div.	762
Electro Arc Mfg. Co.	1465
Electro Circuits, Inc.	2136
Electro Metallurgical Co.	653
Elox Corp. of Michigan	1612
Empire Products, Inc.	1056
Enamelstrip Corp.	346
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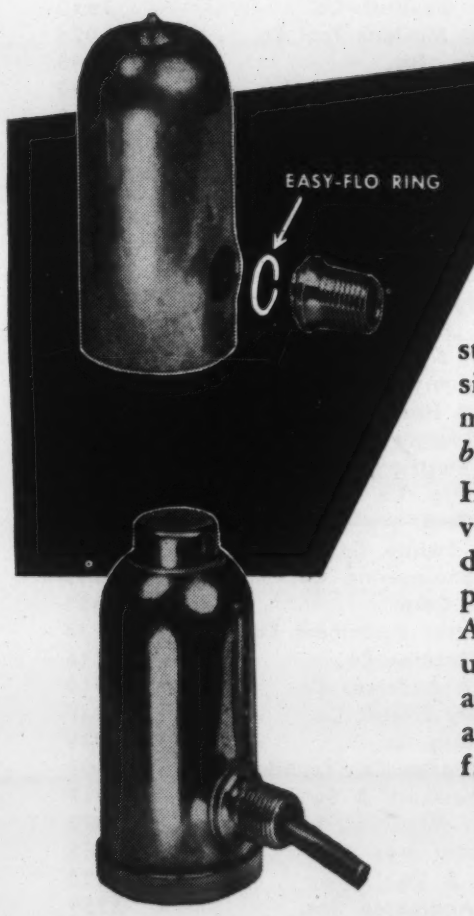
Expert Die & Tool Co.	1330
Expert Welding Machine Co.	1330
Fairchild Engine & Appliance Corp.	2270
Fansteel Metal Corp.	1559
Fawick Airflex Div., Federal Fawick Corp.	1567
Federal Fawick Corp.	1567
The Ferrotherm Co.	2247
The R. Y. Ferner Co., Inc.	1247
Firth Sterling, Inc.	315
Flexonics Corp.	1555
Flow (Publ)	1055
Gaertner Scientific Corp.	2334
Gas Appliance Service, Inc.	854-A
Gas Machinery Co.	854-C
General Alloys Co.	652
General Blower Co.	1545
General Controls Co.	843-J
General Electric Co., Apparatus Sales Div.	1060
Advertising Prod. Operations Carboloy Dept. General Electric Co.	1540
General Electric Co.	1042
General Metals Div.	260
Gleason Works,	454
Glo-Quartz Electric Heater Co., Inc.	1459
Automobile & Aviation Div., B. F. Goodrich Co.	1650
Graham Machine Tool Co.	1025
Gray Co., Inc.	2145
Green Instrument Co., Inc.	1925
Gregory Industries, Inc.	215
Gries Industries, Inc., Testing Machines Div.	702
Gulf Oil Corp.	1560
H. & H. Research Co.	1005
H. & H. Tube & Mfg. Co.	1502
HPL Mfg. Co.	1418
Wm. J. Hacker & Co., Inc.	2310
Grinding & Polishing Machines, Mgr. Machinery Builders, Inc.	1142
Handy & Harman,	342
Harnischferger Corp.	120
Harper Electric Furnace Corp.	1919
Hauck Mfg. Co.	2124
Haveg Corp.	1725
Haynes Stellite Co.	653
Heath Engineering Co.	2340
Heil-Coil Corp.	1655
Heil Process Equipment Corp.	2038
Heller Machine Co.	1116
Heston & Anderson Co.	310
Hevi Duty Electric Co.	247
Higbie Mfg. Co.	1939
Hills-McCanna Co., Foundry Div.	2301
R. C. Hitchcock & Sons, Inc.	2017
Hitchiner Mfg. Co., Inc.	1412
The Hobart Bros. Co.	365
Holcroft & Co.	1220
Holger Andreasen, Inc.	2259
Charles A. Hones, Inc.	854-E
E. F. Houghton & Co.	1010
Howard Foundry Co.	1227
The Hydraulic Press Mfg. Co.	109
Industrial Heating (Publ),	1647
Illinois Testing Labs.	1154
Induction Heating Corp.	2239
Industrial Gauges Corp.	2123
Industrial Heating Equipment Co.	1755
Industrial Press	2018
Industrial Publishing Co.	1055
Industrial Tectonics, Inc.	2249
Industrial X-Ray, Inc.	2211
Industry & Welding (Publ)	1055
Instron Engineering Corp.	2339

(Continued on page 19)

Amazingly simple EASY-FLO or SIL-FOS brazing pays big dividends

Photo and data courtesy of
FLAIR MFG. CORP.,
Brooklyn, N.Y.



It's a safe bet you can get a better product at much lower cost on several of your metal parts by designing them for EASY-FLO or SIL-FOS silver brazed construction – supplemented by a simple production set-up that makes the brazing so easy – *anybody can do it!*

Here's an example – a radiator valve. It is made of a simple drawn body and a screw machine part, brazed with EASY-FLO. And the joining is done on a set-up that "automation-izes" the actual brazing. The net results – a smaller, trimmer valve – and a favorably low production cost.

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The Partlow Corp.	465
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Pyrometer Instruments Co., Inc.	1120
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N. Ransohoff, Inc.	215
Raybestos-Manhattan, Inc.	1201
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J. A. Richards Co.	1453
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Rolle Mfg. Co.	1336
Rolock, Inc.	1724
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"S" Corrugated Quenched Gap Co.	147
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Salem-Brosius, Inc.	241
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A. Schrader's Son	1127
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Scientific Electric	147
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Sinclair Refining Co.	2049
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Solventol Chemical Products, Inc.	347
South Bend Lathe Works	2256
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Southco Div.	2324
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Tin Research Inst.	1901
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Titanium Metals Corp. of America	226
Tocco Div.	160
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Torsion Balance Co., Kent Cliff Laboratories Div.	2343
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U. S. Electrical Motors, Inc.	2012
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Universal Castings Corp.	2148
Uniworld Research Corp. of America	126
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Vanadium Corp. of America	320
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Wells Mfg. Corp.	219
Weltronic Induction Heating Corp.	163
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Westinghouse Electric Corp.	360
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S. B. Whistler & Sons, Inc.	135
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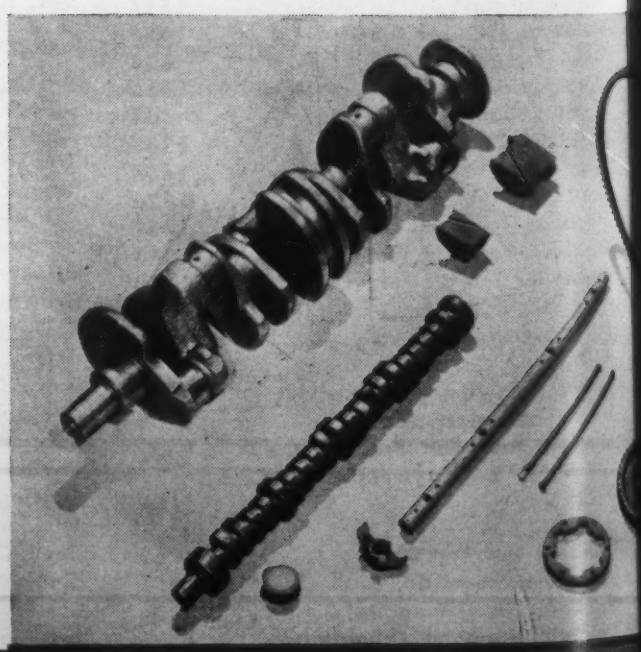

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One point of view

The tyranny of numbers

Over the years many men engaged in engineering activities have become enslaved by numbers. We are thinking particularly of such numbers as are used to indicate dimensions, temperatures, test results, or chemical analyses.

Certainly there is a need for accuracy in technical reports, but the trouble seems to be that highly specific numbers are used to embellish rather general information. Some of our qualified minds, thinking on this particular subject, make pleas for the use of round numbers which convey the proper information but which are easier to remember.

For example, much scientific work is carried on with the aid of the Centigrade scale. When translated for general use, the Centigrade readings are converted to Fahrenheit and the results are often fractional numbers which no one could measure. In one case 413.6 F might better be rounded off at 415 F which would be quite satisfactory for most operations.

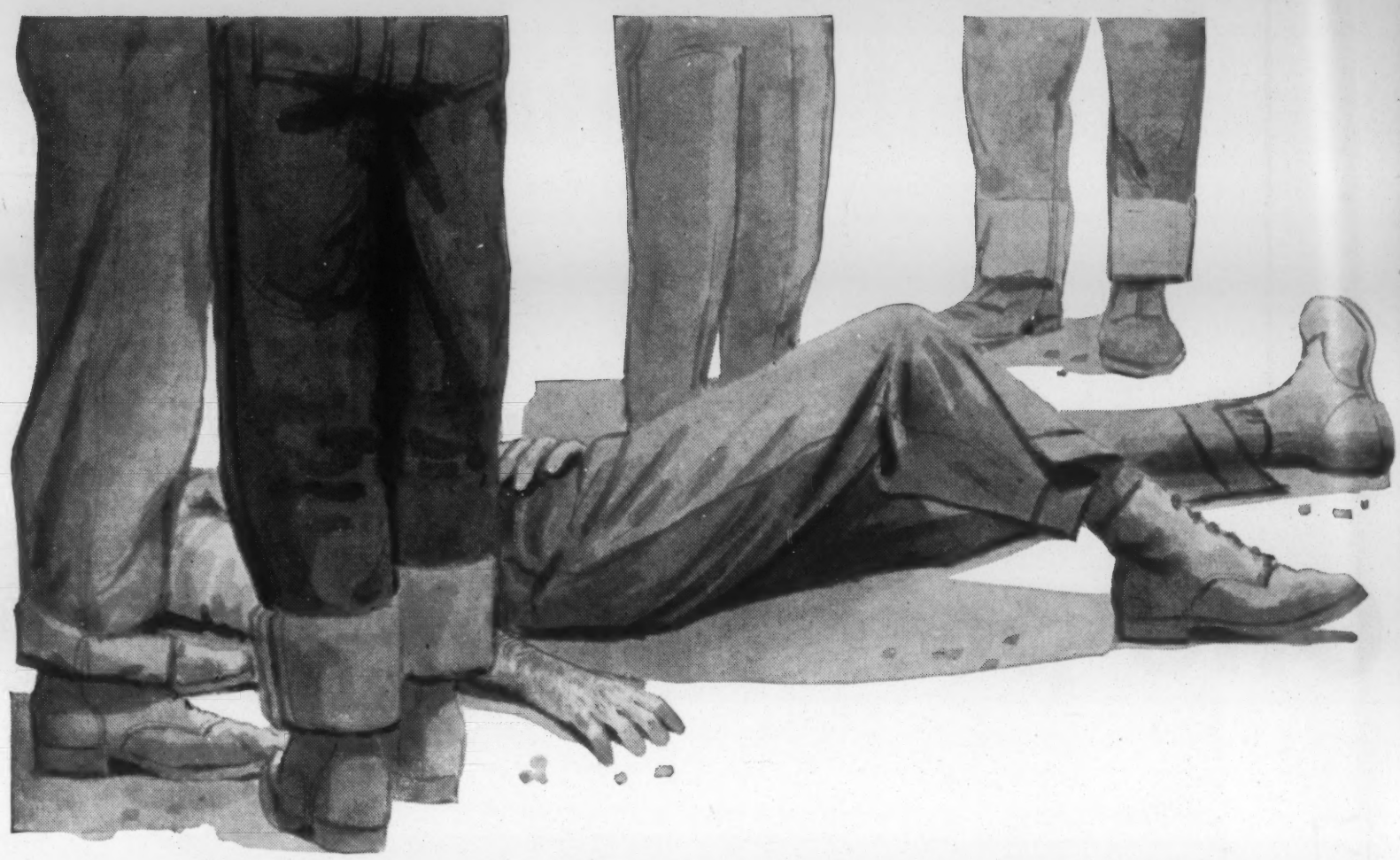
How often have you seen the tensile strength of a material given as 37,533 psi? That doesn't make any more sense than predicting that your expenses next year will total $6,-781.14. Results of that fineness cannot be duplicated in tests, but the tests will show a minimum figure which can be used safely.

However, the worst use of figures today, it seems to us, is in dimensional tolerances. In our constant search for methods of reducing machining and other costly operations we develop processes which offer a high degree of accuracy. In the early stages of the processes, fantastic claims are made as to their capabilities in regard to accuracy. Later, when a process moves from the laboratory to the plant, there comes the sad realization that the hoped for accuracies are not attainable except at excessive cost.

On the other hand, many engineers demand dimensional tolerances which are finer than necessary. Unwittingly they are adding to the costs of the products involved. Ultra-smooth surfaces and accuracies of 0.0005 in. are hard to attain and expensive, and usually are not needed.

We have rambled somewhat in this discourse. The whole point is, learn how to use these important numbers and don't let them get the better of you. There are still many places where exactness to the 5th power is important, but there are many more instances where it is not.

J. C. Du Mond



the "right" alloy steel that failed

A manufacturer wisely chose a certain alloy steel for key strength parts to avoid breakdown and the possibility of human injury. He specified an alloy that should have been right for the job. Yet, the "right" alloy failed. Why?

Since one alloy looks just like another, it might have been a case of mixed steels or it might have been poor response to heat treatment because of the variations that occur between different heats within the same specification. But here at Ryerson we have a plan to protect you from these hazards.

To avoid danger from mixed steels and to tell you exactly what to expect from heat treatment, Ryerson—and only Ryerson—puts every heat of alloy steel through 8 quality-control steps. Every heat is carefully selected, its anlysis verified and its hardenability established by a series of end-quench tests. Every bar is spark tested, positively identified with its own heat symbol and separately racked with other bars from the same heat. And finally, every shipment is carefully inspected and accompanied by a Ryerson Alloy Certificate which includes all test data to confirm analysis and guide heat treatment.

All this extra quality protection is provided by Ryerson at no extra cost to you. So to be sure of your alloy steel—sure of type and quality, sure of what the steel will safely do—call Ryerson for *Certified* Alloy Steel.

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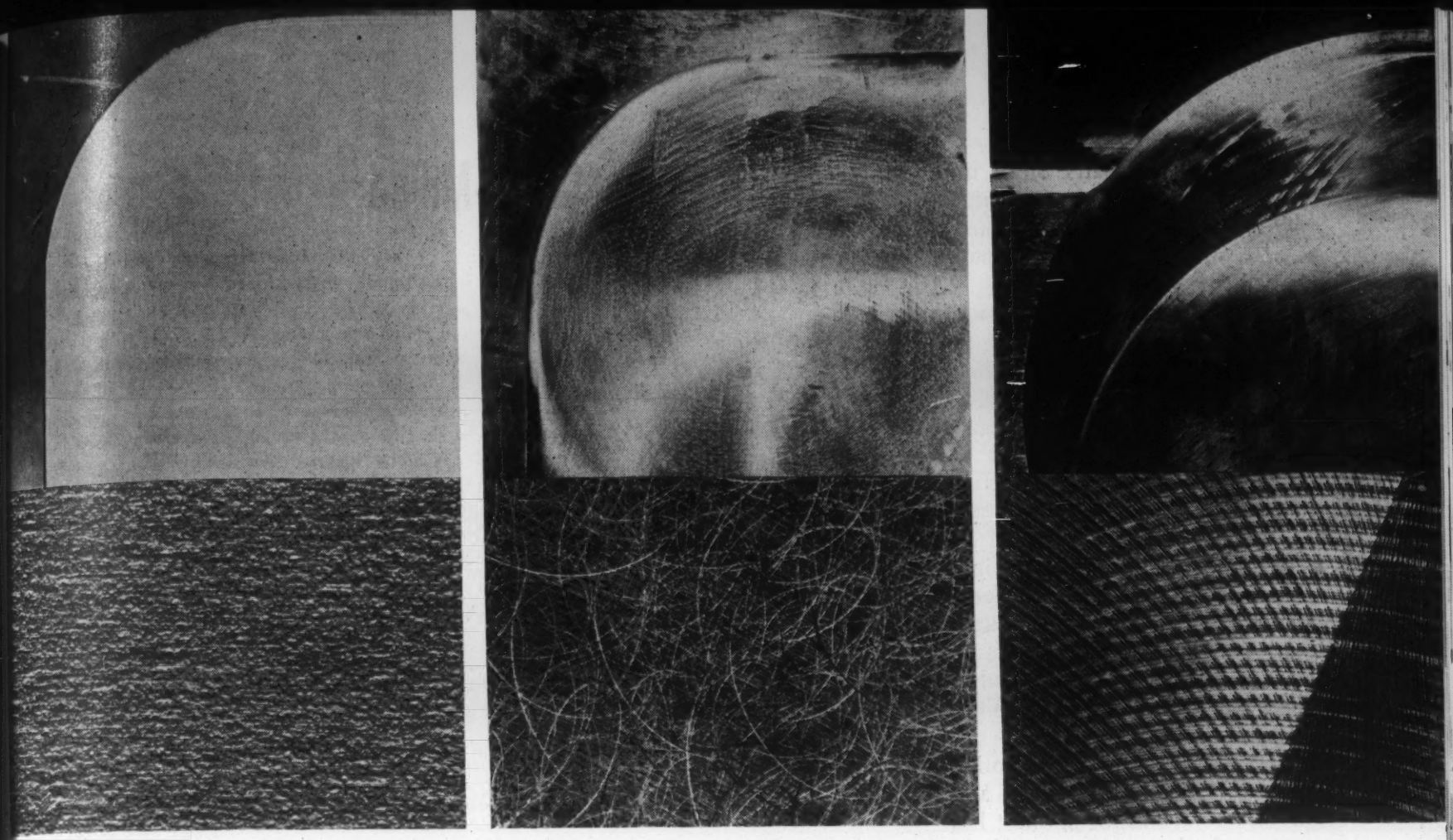


SURFACE ROUGHNESS resulting from chem-milling is on the order of 50-60 microin. rms. Surfaces shown above are chem-milled (left), machine milled and polished (center) and machine milled (right). Lower photos show surfaces magnified.

'Machining' Aluminum by Etching

—gives you greater design flexibility at lower costs

by **MANUEL C. SANZ,** Aerophysics Dept., North American Aviation, Inc.

Chem-Mill process, developed to replace expensive skin milling, also looks promising for steel and titanium.

● THE IDEA OF treating metals by etching is not new. However, use of a precisely-controlled etching process to produce highly complex shapes, non-symmetrical patterns, integrally stiffened structures and tapered skins is distinctly an innovation. Recent success is due to three principal factors: new organic coatings and tapes that resist hot alkaline solutions; modified etching solutions that act uniformly without adversely affecting the metal; and use of measuring and controlling electronic equipment.

So far, the process has been used for steel, aluminum and titanium. Most work has been with aluminum, however, and this article is concerned only with that metal.

In this new process, developed by North American Aviation, aluminum sheet, forgings or extrusions are immersed in a modified hot alkaline solution which etches away the surface at a uniform rate. Areas in which no metal removal is desired are masked. Differential metal removal is achieved by stripping masks intermittently or by gradually immersing or removing the metal from the etching bath.

Advantages

The Chem-Mill process offers both technical and economic advantages over machine milling. Design advantages of the process are as follows:

1. It can be done after forming, whereas only slightly contoured parts can be machined, and forming after machining is extremely difficult.
2. It is not subject to the restrictions on shape of cut, direction of cut and limiting radius that are imposed by machining. Complex shapes, broad or narrow cuts, and comparatively sharp corners can be achieved in one operation, whereas some parts with such design features might require two or more different types of machines for conventional milling.
3. It can be applied to complex

contoured or formed parts. Since, unlike machining, the process permits metal to be removed simultaneously from both sides of a sheet, warpage is avoided.

4. It permits previously impractical lightweight designs, including integrally stiffened structures which need no riveted or welded stiffeners and doublers. Since heavy attachment "islands" can be left on an etched panel, sandwich construction appears more feasible than in the past.

5. It permits reduction in weight of forgings, extrusions and deep-drawn parts which are heavier than required for service either because available standard sizes are limited or because the extra thickness is required for forming.

6. It permits readily-controlled tapering of sheet, extrusions and various structural members. Sheet has been tapered down to a uniform thickness as low as 0.002 in.

7. It permits various depths of cut on one part in a single operation.

8. It permits a tolerance on sheet thickness as low as 0.002 in., compared to 0.010 in. for machine milling.

An early limitation of the process was the restriction on maximum depth of cut to 0.5 in. when masking is necessary. The reason for this limitation is explained by the accompanying diagrams. Improved techniques, however, now make it possible to cut deeper than 2 in.

Following are the principal economic and operational advantages of the process:

1. It lends itself to automation by electronic instrumentation and no highly skilled operators are required.

2. It can handle many parts simultaneously, the number being limited only by the size of the etching tank. This makes possible more flexible scheduling of fabricating operations.

3. It eliminates the need for subsequent mechanical finishing operations, since notches that reduce fatigue life are not created as they are in machine milling. Conventional milling of thin skin sections must be followed by hand polishing with rotary or vibrating sanders.

4. It utilizes conventional equipment of the type required for metal cleaning and generally already available in the plant.

Parts to be Chem-Milled May Need . .

. . . NO MASKING

Many forgings, extrusions and formed parts can be reduced in weight by chem-milling.

Forgings often must be made with webs of a certain minimum thickness that is greater than needed in service. Chem-milling removes metal from all surfaces simultaneously, thus preventing warping due to internal stresses. Weight reduction by machine milling is always costly and often impossible on forgings of intricate design. It is also possible for chem-milling to replace rough machining of forgings.

Extrusions are often heavier than necessary, either because of the limits of the extrusion process or because of limits on standard sizes available. In addition to general metal removal, extrusions are

. . . SIMPLE MASKING

Many parts require only simple masking by templates or adhesive tape.

Tubing with a larger outside diameter than necessary can be reduced in weight by plugging the ends and etching down the exterior surface. Where the outside diameter must be maintained, the same result may be achieved by masking the exterior surface and etching down the interior surface, thus increasing the inside diameter.

Parts can be made with various depths of cut in different sections of the same panel by masking with adhesive tape and

. . . COMPLEX MASKING

More complex integrally stiffened panels, such as the "waffle" type, can be made by silk-screen or photosensitive-coating masking. Matching panels of this type provide a sandwich construction that has a stiffness-to-weight advantage of four or five to one over sheet of equivalent weight per unit area. Even on flat panels,

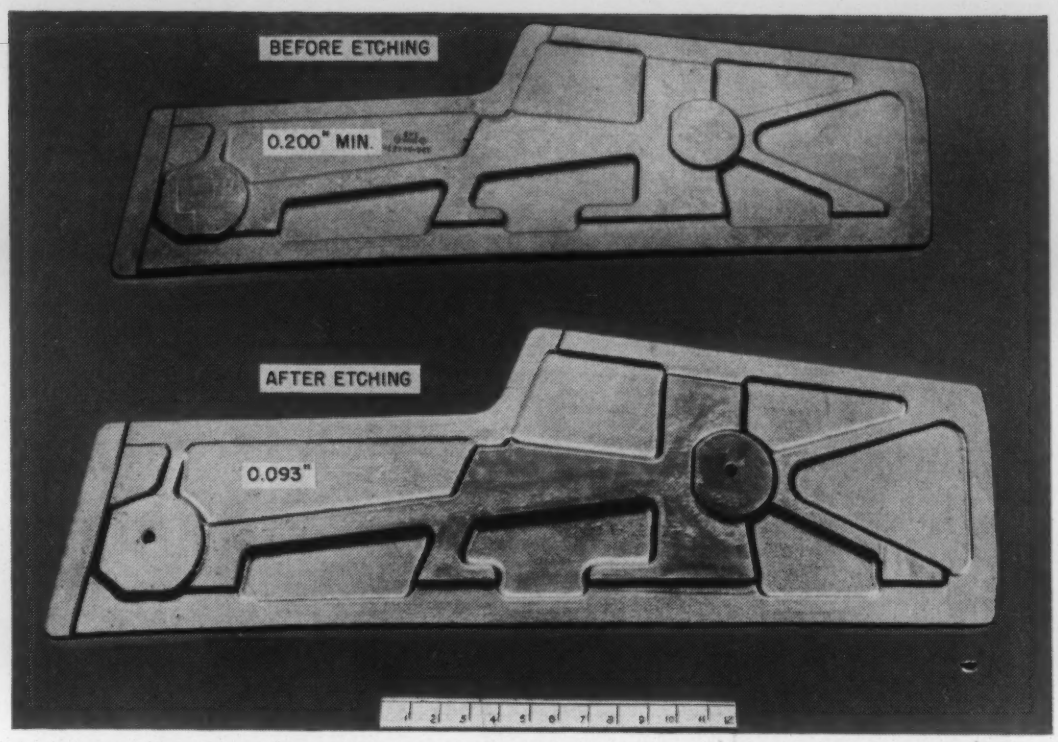
Effect on the Metal

Bend, tensile and fatigue tests indicate that the mechanical properties of the metal are not impaired by chem-milling. Bend test results on both chem-milled and machine milled sheets, ranging from 0.032 to 0.068 in. thick, were satisfactory for a bend radius of three times metal thickness. Chem-milled sheet was not as satisfactory as machine milled sheet for a bend radius of twice metal

often subjected to tapering by gradual immersion or removal from the etching tank. Tapering is also applied to other load-carrying members such as stringers, longerons and skins.

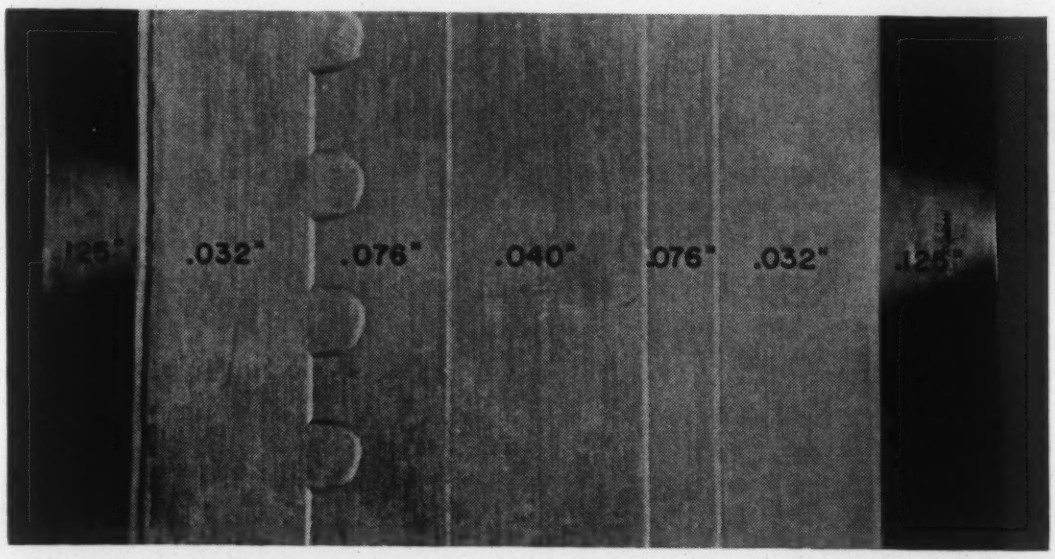
Formed parts require sheet of certain minimum thicknesses to prevent cracking in sharp corners. Chem-milling does not result in significantly different rates of metal removal in stressed and relatively unstressed areas.

The suitability of chem-milling for castings is now being investigated. After penetrating the cast "skin", the etchant enters the pores and causes craters to appear on the surface of the casting. Whether such a surface is unobjectionable in certain applications has yet to be determined.

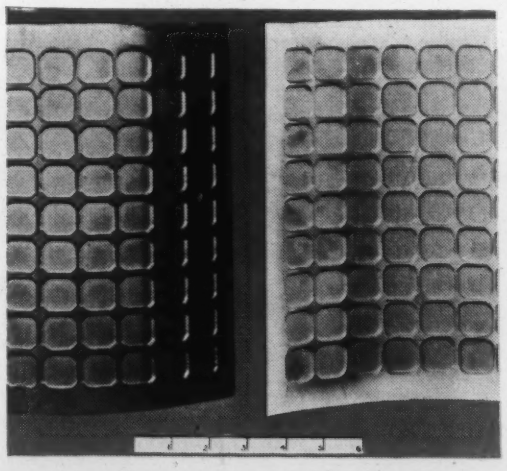


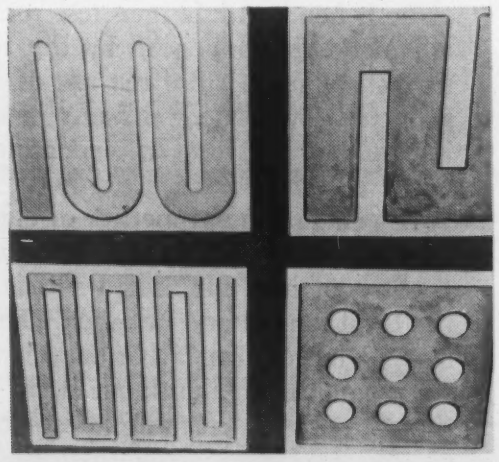
removing different sections of the tape at appropriate intervals.

Integrally stiffened flat or formed panels can be made by masking areas where "islands" or stiffeners are required. Chem-milling permits cuts not possible by simple machining operations. It also eliminates rivets and other mechanical attachments—a definite advantage where pressure tightness is required, as in integral fuel tanks or pressurized cabins. The panel shown here is an example of a part which has been step-etched by tape masking.



such a design would be uneconomical by machine milling. Chem-milling makes it possible to accomplish the design after the panel has been formed. Similar techniques for matching panels were used in the design of the heat transfer plate of which four different versions are shown here.

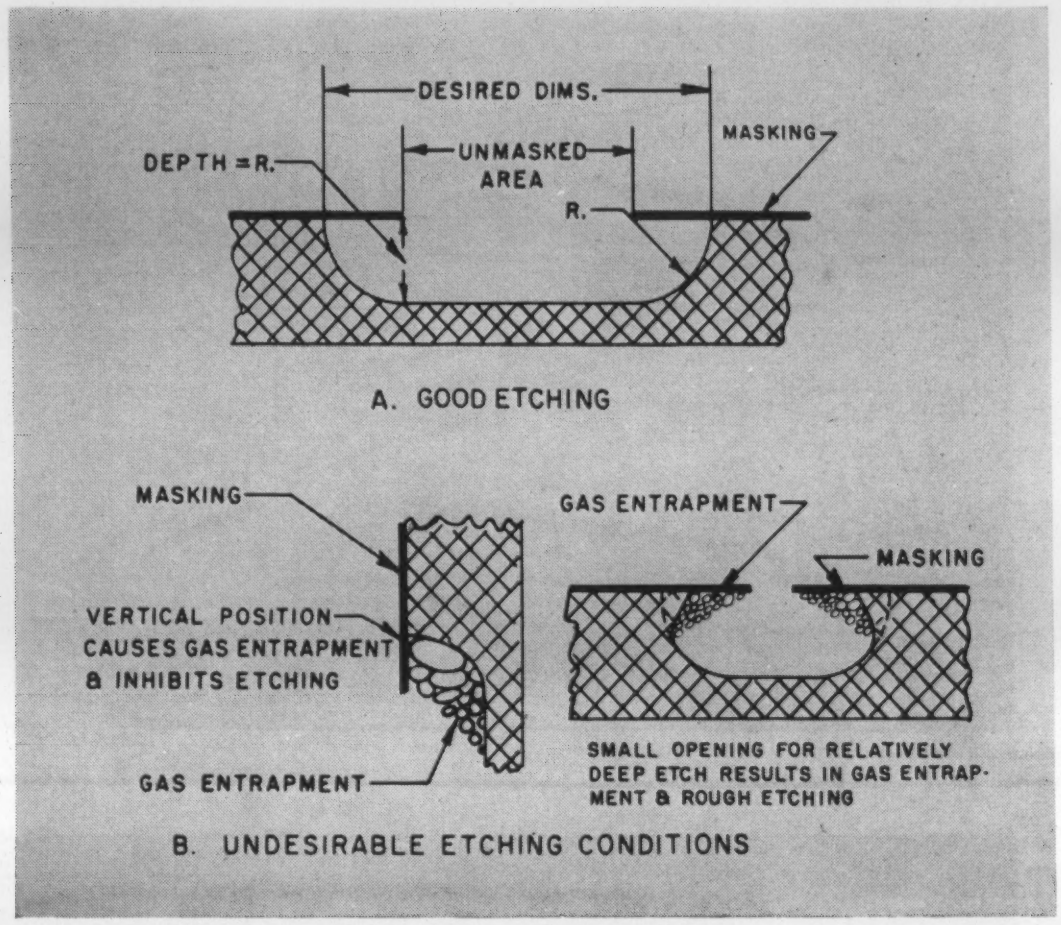




thickness, but this test is not required by most engineering standards.

Tensile tests on etched clad 24S showed an increase in strength as would be expected, since the lower-strength cladding was removed from one side of the sheet. Parent stock 1/8 in. thick had a tensile strength of 60,000 psi and elongation of 12%, whereas the etched material, 0.035 in. thick, had a tensile strength of 61,700 psi and elongation of 15%.

Flexural fatigue tests on parent, chem-milled and machine milled aluminum sheets at stresses of 38,000



***DEPTH OF CUT** is currently limited to a maximum of 1/2 in. when masking is necessary. Since the etchant attacks the metal uniformly, it produces a radius at the edge equal to the depth of cut. Gas produced by the chemical reaction tends to collect under the protruding mask and slow the reaction, causing uneven etching. Various methods of overcoming this limitation are being investigated.*

and 48,000 psi indicated only small differences in properties. The advantage of about 2000 psi for chem-milled sheet over machine milled sheet at the 48,000 psi level, as shown in the graph, might be due to the difference in thickness of the parent sheets from which it was necessary to prepare the 1/16-in. thick specimens.

Both bend and fatigue test results are markedly influenced by the type of etchant used, since the use of improperly formulated etchants results in rougher surfaces and consequent notch effects.

In general, the properties of chem-milled sheet are practically the same as those of machine milled sheet that has been sanded and polished. These test results confirm earlier experience, since etching of aluminum parts for the purpose of cleaning, decoration or metallographic examination has been done for many years without any indication of detrimental effects.

No comparative corrosion tests have been run on chem-milled and machine milled parts. Since microscopic examination of chem-milled parts reveals no intergranular attack and no change in chemical composition of the surface, however, no difference in corrosion resistance between chem-milled and machine milled parts is expected

The Process

The three vital elements of the process are the etching solution, the masking techniques and the process controls.

Solution—The strongly alkaline solution currently used for chem-milling is supplied by Turco Products, Inc., of Los Angeles, Calif. Details on composition have not been released. However, the solution has been modified in the direction of promoting a smoother surface, more uniform action, better wetting and easier disposal of by-products.

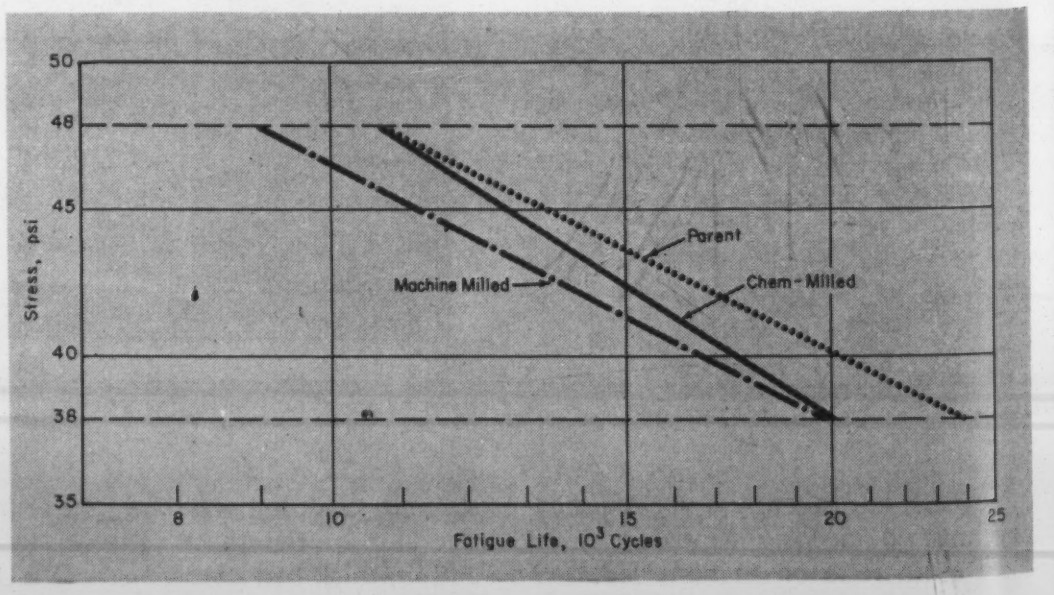
By-products of the exothermic reaction are hydrogen gas, alumina and metallic compounds. They present no special problems. The hydrogen, a potential hazard, is now being removed by conventional electroplating tank vents without any effort at recovery. Solids are removed by centrifuging, permitting continuous and uniform operation of the etching bath. The recovered solids are presently being disposed of as waste, but they will probably be marketed when the process enters full production at North American's Downey, Calif., plant.

Although the etchant now used is alkaline, both acid and electrochemical baths are also being investigated.

Masking—Several different masking methods can be used to obtain selective etching. In order of greatest economy, they are:

1. Templates. This method utilizes a pattern plate and a rubber seal, both with the design cutout, plus a base plate and metal gaskets. The template may be held by clamps, bolts and nuts, or by vacuum. All materials must be resistant to the etching solution. This mechanical masking method can be applied to parts with simple curvatures but not to parts with cross ribs or stiffeners.

2. Adhesive Tapes. This method is particularly satisfactory for "step etching" where a single panel is chem-milled to more than one depth.



***Fatigue properties** of chem-milled aluminum sheet compared to those of parent stock and of machine milled sheet.*

The chemically resistant tape is stripped off progressively after etching begins on the deepest or thinnest sections.

3. Organic Coatings. For fairly simple designs, templates can be used with brushed or sprayed chemically resistant coatings. For more complex designs on flat or slightly contoured panels, a silk-screen process can be used. A stencil of the design is painted, cemented or photographically reproduced on a fine-mesh silk screen, and a specially compounded semi-liquid pigment is squeegeed through the screen to form the design on the metal surface. For matching parts of complex contours, a photosensitive coating can be used. The coating is applied to the part in a darkroom, a glass cloth negative is positioned over it, and photoflood lamps are used to expose the coating. The unexposed material is washed off and the sensitized material forms the mask.

4. Electroplates. This method has been used successfully by North American's Columbus, O. division. The part of the sheet to be chem-milled is masked by conventional electroplating techniques and the unmasked areas are copper-plated. The original masking is then stripped and the copper plate acts as the mask for chem-milling.

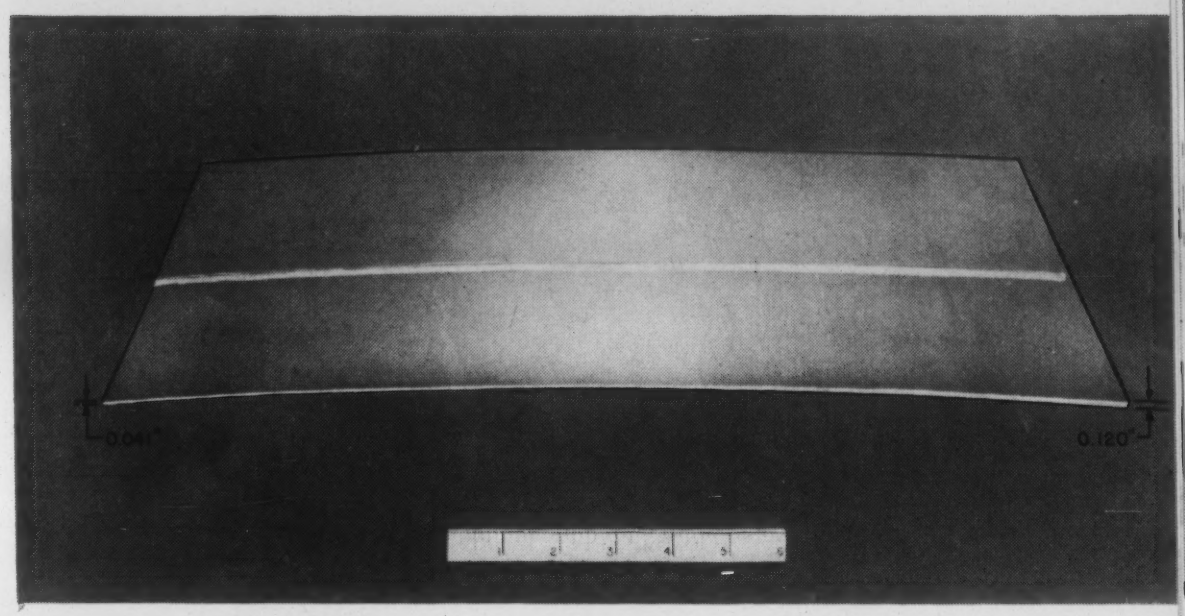
Controls—Currently, the principal control is one that determines how much metal has been removed from a part in the etching tank and is designed to ring an alarm or trigger a mechanism to remove the metal from the tank when the predetermined depth of penetration has been reached. Now being tested is a device that will control etching rate and chemical concentration of the solution. Other electronic devices are being developed to control rate of immersion or removal of the metal so that accurately tapered parts can be produced.

Cost

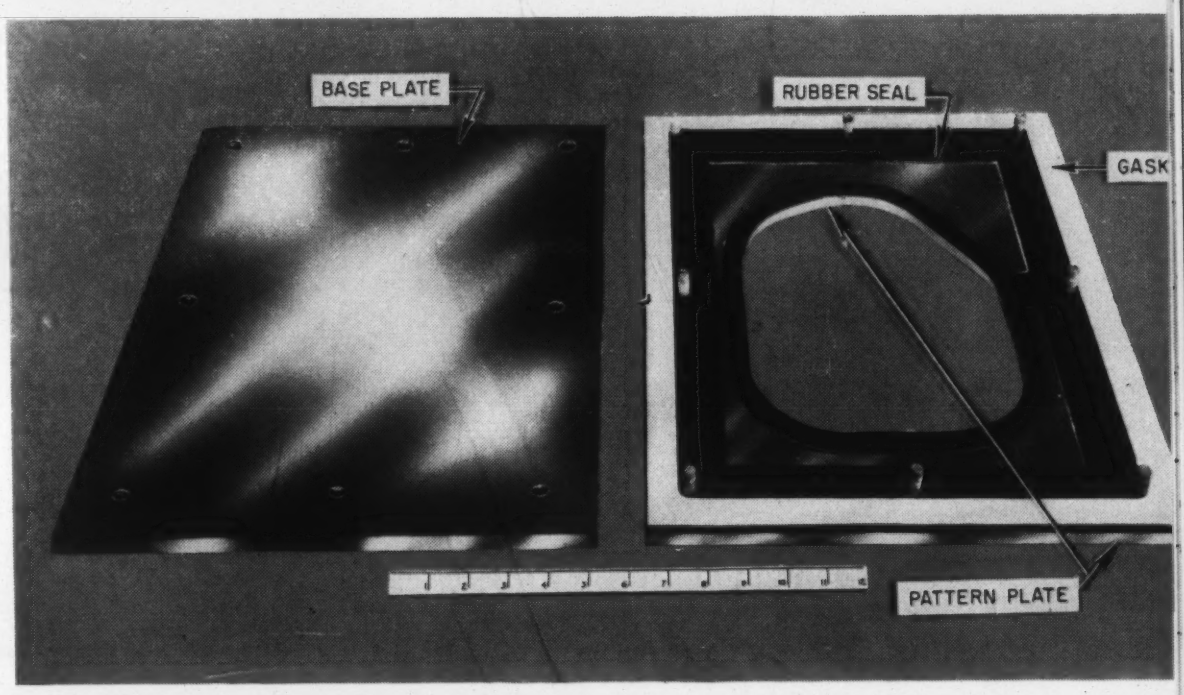
Cost comparisons show a considerable advantage for chem-milling over machine milling. The cost of chem-milling, unlike that of machine milling, is not reduced substantially as production quantity increases. On the other hand, many parts that can be chem-milled are economically impossible to consider for machine milling and no significant cost comparisons can be made.

Operating costs increase with the complexity of the masking required. Based on a tentative cost of $0.18 per lb of etchant, the operating cost per lb of aluminum removed is $0.27 where no masking is required, compared to a conservative figure of $1.00 for machine milling. For template masking, the cost of tooling and of the clamping and unclamping labor must be added, but this cost is low and the tooling does not deteriorate in the solution. For masking by tape, paint and silk-screen methods, the cost of the masking materials and of the application and stripping labor must be added. A preliminary cost survey on one production part showed figures of $9.36 per part for chem-milling with paint spray masking, $25.00 for machine milling at North American's Downey plant and $80.00 per part for machine milling in 60- to 150-part lots by a subcontractor. Cost figures for photosensitive-type masking techniques are not yet available, pending more complete development of the process.

From the standpoint of initial equipment requirements, the cost of a complete Chem-Mill setup has been estimated at about $30,000. If a conventional metal cleaning installation should be available, the initial cost would be considerably reduced. A study of one particular manufacturing requirement, where parts had to be released on a definite time schedule, showed that three milling machines, costing about $600,000, would be required to do the job of a $30,000 chem-milling setup. A chem-milling installation of this size would occupy about 5000 sq ft.



Aluminum sheet tapered by chem-milling. Uniform thicknesses as low as 0.002 in. have been achieved by tapering.



Template masking tool with base plate removed.

Powdered glass (left) made from crushed glass (right) is formed into parts that retain desirable characteristics of glass by new technique.

Pressed and Sintered Glass Powder Shapes Provide

- Intricate Design
- Close Tolerance
- High Properties

by **WILLIAM H. McKNIGHT,** Corning Glass Works

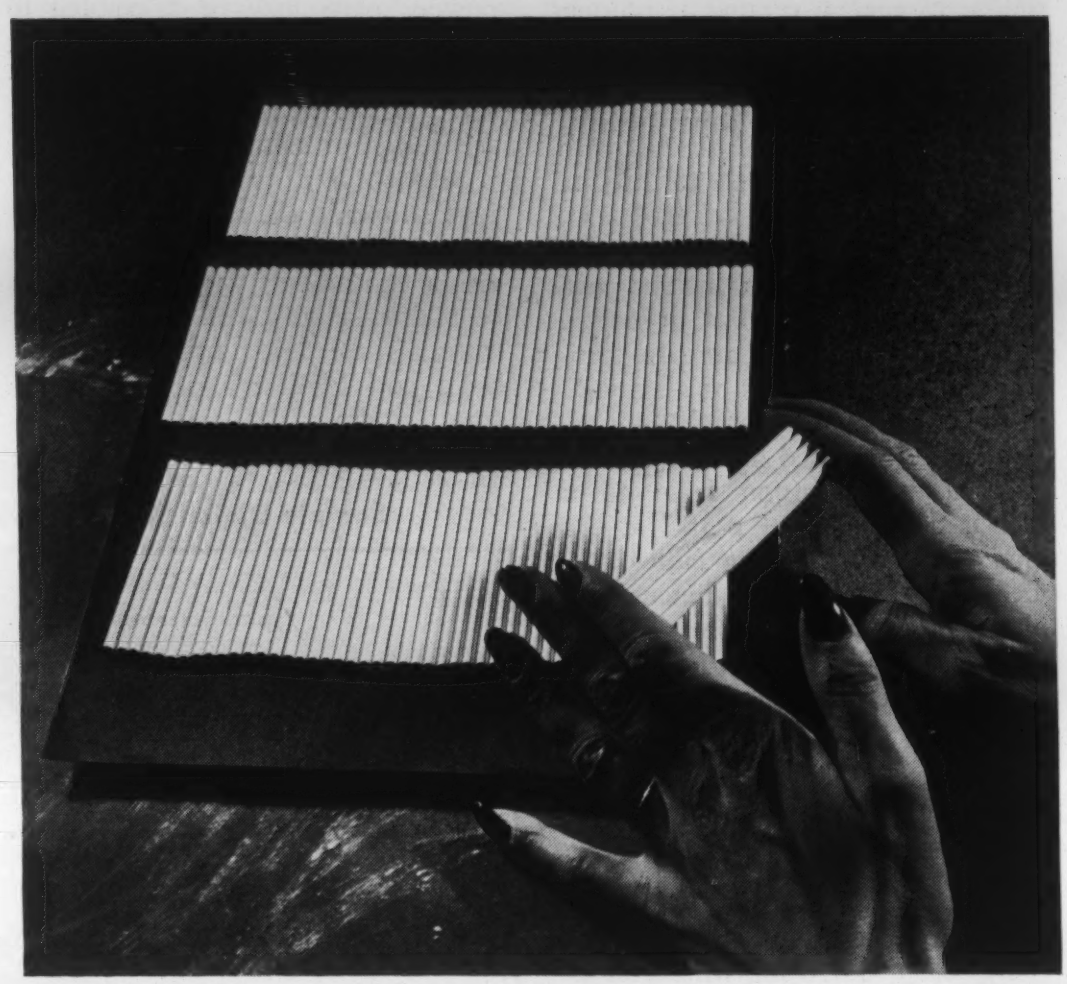
● A RECENT DEVELOPMENT in the technology of glass fabrication closely resembles powder metallurgy. Called Multiform, it is a cold-glass-working technique, which allows the forming of glass into a wide variety of precise shapes and intricate patterns which would be impractical with conventional molten glass-forming techniques. Powdered glass is mixed with a binder, molded, and sintered to form a vacuum-tight monolithic structure with a density of about 98% that of an equal volume of the parent glass. The resultant parts retain the desirable characteristics of glass, such as thermal endurance, corrosion resistance and dielectric strength. The material is opaque, and normally white though colorants may be introduced if desired.

Properties and Characteristics

The physical and electrical properties of the glass from which the sintered compact is made are left essentially unchanged in the finished part. The mechanical strength is slightly less than that of a part made of solid glass. However, for most applications, this difference is negligible.

One characteristic of sintered glass forms not found in glass worked by other methods is its lack of continuous bubbles. Conventionally formed glass has occasional seeds or blisters formed by entrapped gas. In drawn tubing and cane, these take the form of elongated seeds or hair lines. In the early phases of television picture tube manufacture, when glass cane was used within the neck of the tube for electrode mounts, this trapped gas created a prolbem. Sintered glass powder rods have proven to be a satisfactory solution, and many television tube manufacturers use them today.

Most types of glass lend themselves to Multiforming, some being especially adapted to the process. This permits a wide choice of materials with varying coefficients of thermal expansion. Sealing beads or other items can be made of types of glass with expansion coefficients matching those of numerous materials such as tungsten, molybdenum, platinum, carbon steel, 17% chromium steels, Dumet, Kovar and mica. The selection of the parent glass to be used depends on requirements of the finished part, such as the ambient service conditions, expansion and electrical characteristics, etc.



The lack of air or gas inclusions makes Multiform well adapted for use as cathode ray gun mounts.

Properties of Glass
(Multiform vs. Parent Glass)

	Multiform			Parent Glass	
	96% Silica (Vycor-Brand—7900)	Pyrex (7761)	Pyrex (7070)	Conventional Pyrex (7761)	96% Silica (Vycor-Brand—7900)
Lin coef exp, 32-570 F, per deg x 10^{-7}	4.7	18.4	17.8	18.4	4.2
Max service temp, F	1470	840	860	840	1650
Softening point, F	—	—	—	1435	2730
Mod of rupture (glazed) annealed, psi	6000 to 10,000 (Depends on size, shape, etc.)				
Strengthened (factor of increase over annealed)	1.5	2.0	2.0	4.0	—
Specific gravity	2.15	2.12	2.10	2.23	2.18
Approx volume resistivity, log R at 480 F (ohms/cu cm)	9.8	12.0	11.2	9.4	—
Log R at 660 F	8.1	10.0	9.1	7.7	—
Approx power factor at 68 F, 1 megacycle	0.10 0.16	0.10	0.08	0.18	0.05
Dielectric constant at 68 F, 1 megacycle	4.0	4.0	4.0	4.5	4.0

The surface of a Multiform shape is smooth but slightly more irregular than hot-molded glass. This feature is generally desirable where surface irregularities are critical for metallizing and stamped paint designs. On parts where surface electrical conductivity is important, the longer path provided by the slight irregularities is usually advantageous. If necessary, the surface may be fire-polished.

Shapes, Sizes and Tolerances

In designing parts to be manufactured by the process, the requirements of straight press-type dry molding should be kept in mind. Irregular surfaces should be perpendicular to the press stroke and axes of holes should be parallel to it. Undercuts and re-entrants should be avoided and generous radii should be allowed between heavy and light sections. Where large pieces, irregular shapes or small quantities are required, shapes may be slip-cast by a method

similar to general ceramic technique.

The dry-pressing method allows a wide variety of possible shapes. Typical shapes produced by the method are beads, cylinders and headers with o.d. ranging from 0.060 to 2.0 in., with a minimum i.d. of 0.030 in. Also produced are television gun mounts 0.157 in. in height and width, and 0.787 to 6.0 in. in length. Graded seal cylinders are also produced to join two types of glass with differing expansion coefficients. One cylinder is composed of 8 rings with a graduated expansion from 46 x 10^{-7} at one end to 8 x 10^{-7} at the other. An accompanying table indicates normal and special dimensional tolerances held in dry-press Multiforming. Design, of course, affects tolerance, and finer tolerance can be obtained by grinding or polishing when necessary.

Large or irregular pieces which do not lend themselves to the dry-pressing technique can be slip cast with holes and re-entrants at any required angle. Tolerances can be held to ± 1% or ± 0.010 in., whichever is greater. The major limitation to slip-casting is that only the 96% Silica (Vycor Brand) and fused silica glasses are suited to the method. Though exceptions are possible, the present size limitations on parts made by this method are as follows:

Maximum Weight	60 lb
Maximum Height	8 in.
O.D.	½ to 28 in.
Minimum Wall Thickness	3/16 in.

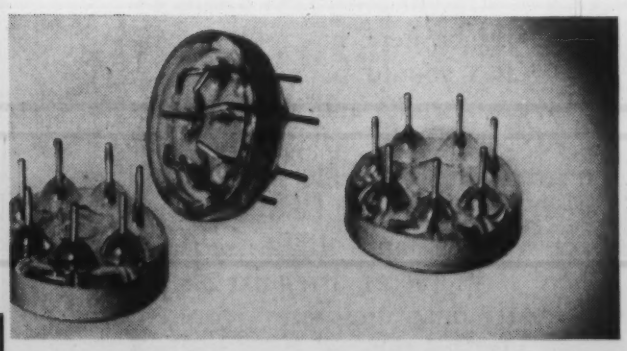
Both slip-cast and dry pressed parts may be furnished in a semi-fired state. In this condition the glass is fairly fragile, but it can be machined by conventional metal working tools to make such items as experimental design samples. After machining, the semi-fired form must be fired to complete the sintering. Sintered glass powder parts may be assembled to metal parts by soldering, allowing the inclusion of such items as silvered bands and printed circuits in the design of components.

Multiform parts are finding many applications in the rapidly expanding electronics industry. As well as television gun mounts, leads which must be hermetically sealed through other materials are being produced. Tube bases and headers for potted electronic components are being constructed with accurately spaced holes and shoulders. Glass cases with high dielectric strength and low loss are being formed for use as hermetically sealed containers. Two of the most recent items are pill-size cases for transistors and diodes. For the chemical industry pipe line filters, bubble caps and perforated plates for fractionating columns, and chemical pump sealing rings are providing valuable applications for this new type of glass form.

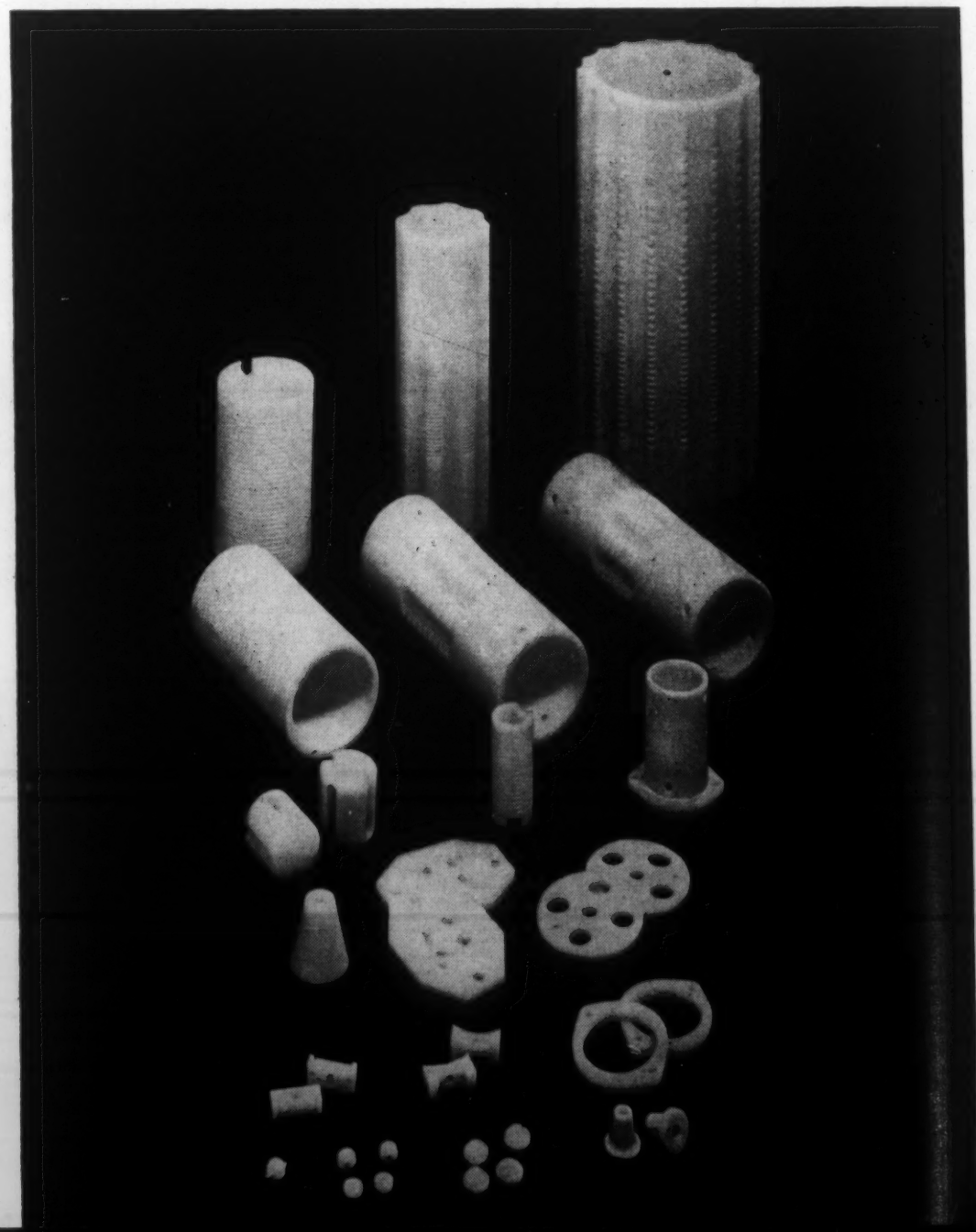
Sample Dimensional Tolerances for Dry-Press Multiform

Typical Tolerances			Special Tolerances	
Nominal Dimension, in.	Dia., in.	Thick. or Length, in.	Dia., in.	Thick. or Length, in.
0.000–0.199	±0.005	±0.008	±0.003	±0.005
0.200–0.299	±0.006	±0.010	±0.009	±0.007
0.300–0.799	±0.007	±0.006+1%	±0.005	±0.003+1%

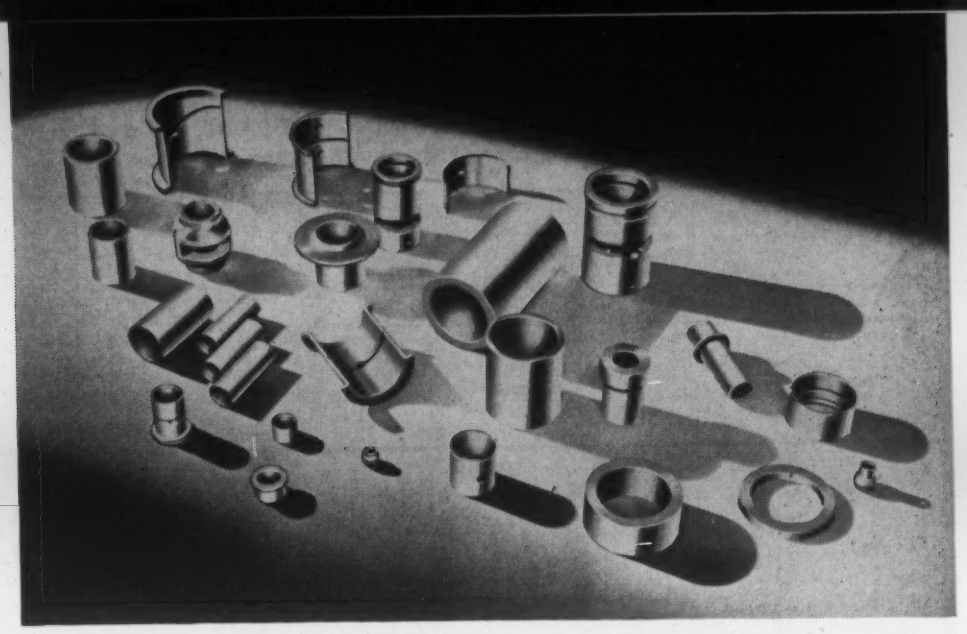
Metallic elements can be easily fixed to the glass as illustrated by these multiple leads of a glass-metal header.



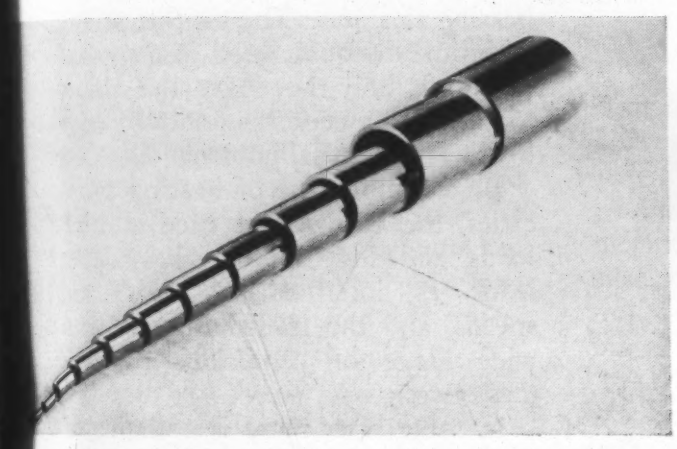
Parts can be either dry-pressed or slip-cast, and a wide variety of shapes formed.



Solid bronze and sand castings before machining, used for cylindrical and flanged sleeve bearings.



Various shapes used in sleeve bearing applications. (All photos courtesy Johnson Bronze Co.)



A range of bushing sizes bored from a single solid bronze bar.

Used alone or in combination with other bearing materials,

Copper Alloy Bearings

meet a wide range of service requirements.

by J. B. MOHLER, Consultant

● COPPER ALLOYS in various bearing constructions have a wide range of bearing properties that fit them for many bearing applications. Used alone or in combination with steel, babbitt and graphite, the bronzes and copper leads meet extreme conditions of load, speed and lubrication. A partial list of bearing constructions is shown in the accompanying box. Further modifications of these combinations are also used.

The range of bearing properties of the copper alloys has been greatly extended by the use of electrodeposited overlay alloys, and by the use of sintered powdered metals. To meet present day requirements for high speeds and loads, multiple layer bearings have been developed using bronze as a backing, a surface layer or an intermediate layer between a steel backing and an overlay white metal alloy. To meet requirements for restricted lubrication porous bronze bushings have been developed. Each of these bearing structures fills a need for a specific field of application, but the bearing properties of the bronze alloys used are essential to the performance of the bearing.

Alloys and Forms Available

Bronze alloys are available from many sources and in a number of forms. They are generally made as castings to a print. They are also available as standard bar stock in solid, hexagonal and hollow bars as S.A.E. 660 alloy (83 Cu, 7 Sn, 7 Pb). Also a great many general purpose bronze bushings are manufactured in stock sizes. In addition, many bronze bushings of wide use, such as electric motor bushings are available as standard replacement parts.

Solid bronze bearing stock is made by sand casting, permanent mold casting, investment casting, centrifugal casting and continuous casting. For a particular alloy, a considerable range in properties can be obtained by casting methods that result in rapid freezing of the metal as compared to sand casting. However, the properties of the bronzes are more easily changed by the addition of tin, lead or other metals to the alloys than by changing the casting practice. Therefore, for practical purposes it is best to consider the alloys rather than the casting methods.

Copper Alloy Bearing Constructions

- Cast Bronze
- Cast Leaded Bronze
- Cast Copper Lead
- Wrought Bronze
- Bronze on Steel
- Copper Lead on Steel
- Copper Lead with Overlay
- Gridded Copper Lead
- Graphited Bronze
- Sintered Bronze

Table 1—Copper Base Bearing Alloys

Composition, %				Ten. Str, psi	Hardness Brinell
Cu	Sn	Pb	Zn		
90	10	—	—	38,000	70
80	10	10	—	32,000	65
85	5	5	5	34,000	60
83	7	7	3	34,000	60
85	5	10	—	30,000	60
80	5	15	—	30,000	55
70	10	20	—	28,000	55
70	5	25	—	21,000	48
75	—	25	—	18,000	42

Hundreds of copper alloys could be listed as bearing alloys. In fact, any copper alloy is a potential bearing alloy, since the variation in bearing requirements is broader than the range of properties covered by the copper alloys. On the other hand, the majority of applications for the bronzes can be taken care of by a relatively small number of alloys.

The copper bearing alloys are of three types: 1) the bronzes containing copper and tin, 2) the leaded bronzes containing copper, tin and lead, and 3) the copper leads. These might also be referred to as the hard, intermediate and soft alloys. A listing of alloys and the approximate strength and hardness of sand castings is shown in Table 1.

Basically the alloys are copper-tin-lead alloys. Zinc is usually added for casting purposes to deoxidize the metal and increase fluidity during casting. Phosphorus is added as an alternative for the same purpose. Lead is sometimes added to the bronzes as a minor element to increase machinability rather than for bearing purposes. Aluminum, silicon, beryllium, antimony and nickel may be added to increase the mechanical properties and to increase wear resistance. Nickel may be substituted for some of the tin to produce a heat-treatable alloy.

It is by the use of these minor elements that many alloy variations have been produced. Special properties may be obtained by the use of such alloys, but lower costs are possible by the use of a standard alloy to a standard specification.

Bearing Properties

Sleeve bearing materials must meet a large number of requirements. Failure to satisfy any one of them may mean an unsatisfactory material.

The material must have sufficient bearing load capacity. Where the load is high and is the most important factor, the hard bronzes are often the only alloys that can be used. A closely related factor to load capacity is resistance to pounding. The alloy must not only endure the unit loading, but in many cases must also withstand shock loads or repeated pounding.

The alloy must be resistant to seizure. The coefficient of friction for a specific application must be sufficiently low to avoid build-up of heat with eventual galling, pick-up of metal by the shaft and finally seizure. At higher speeds, coefficient of friction becomes important and it is often necessary to use a copper-lead alloy with a supply of free lead available in the alloy to provide seizure resistant properties. When seizure is a prime factor, the softer alloys must be used at sacrifice of load capacity.

In many bearing applications the alloy selected is a compromise between high load and high speed properties. None of the copper alloys can be used for high loads at high speeds, but they do satisfy a great range of other speed and load applications. Table 2 is a general listing of how the copper alloys can be used at various speeds and loads.

A sleeve bearing alloy must have good wear resistance to avoid frequent replacement. The hard alloys are generally more wear resistant than the soft alloys. On the other hand, a hard alloy will cause more shaft wear than soft alloys. This condition is corrected either by using a hard shaft or by using a softer bearing alloy and replacing bearings rather than undergoing the expense of replacing the shaft.

Bearings must be sufficiently soft to engulf or embed harmful particles. Most wear in bearings is abrasive wear due to presence of gritty particles. Grit between the bearing and shaft not only causes wear but can generate heat and promote seizure.

The bearing alloy must also have an adequate elasticity and plasticity to move both temporarily and permanently under the influence of forces that might otherwise destroy the bearing clearance. The conformability of bronzes is quite good in many applications and they have the ability to adjust to a certain amount of edge loading and misalignment.

By a compromise of bearing properties, the bronzes are used at high loads and low speeds, the copper leads at intermediate loads and speeds, and the leaded bronzes at a wide range of conditions between these two.

In some cases there is a choice of bearing materials. It may be possible to use copper lead as an alternative for a babbitt-lined bearing. A solid, cast, copper-lead bearing will often be cheaper than a lined bearing, particularly for full round bearings and heavy wall bearings. Machinability may also be a factor. The leaded bronzes can be machined to a good finish at high speeds.

Bronze sand castings can be made in relatively intricate shapes of high

Table 2—Load and Speed Capacities of the Copper Alloys

Speed	Load		
	High	Int.	Low
Low	Bronze	Bronze	Bronze
Int.	—	Copper-Lead	Leaded-Bronze
High	—	—	Copper-Lead

strength. Because of these possibilities, castings are often made for multiple purposes. The casting may serve as a bearing and also function as a structural part. It may contain flanges and bosses or it may be machined or threaded to service a double purpose.

Design Factors

Besides the problem of selecting the proper alloy to meet the bearing requirements, there are other considerations such as design and lubrication that are closely related to the bearing material selected. Many bearing failures are unjustly blamed on the material. The bearing alloy is limited as to tolerance for misalignment, improper clearance or insufficient lubrication. Failure can also be due to the design of the bearing. Placement of oil holes and oil grooves depends on whether forced lubrication is used, or whether lubrication depends on the pumping action of the moving shaft in conjunction with a drip or wick feed. The oil must be carried to the high load area of the bearing, along the entire length and in sufficient volume to keep the bearing surface cool. Mud pockets may also be used for collection and flushing away of dirt.

The length of the bearing is important. If it is too short the unit loading may be high, and if it is too long the oil film may be broken due to shaft deflection. There are also limitations on clearance. Sufficient clearance is required to take care of dimensional tolerances and thermal expansion of the bronze, but the diameters of the shaft and bearings must not be too different if sufficient bearing area is to be provided. In critical applications alignment becomes important and it is often necessary to bore after the bearing is in place. Specifications for clearance, dimensional tolerances, oil grooving, load and speed capacities vary considerably.

Applications

In almost all applications where solid bronze bearings are used they are eventually replaced due to wear. Where pounding, fatigue, or high speeds at high loads become the limiting factors, the multiple layer bearings are generally used. However, a great many of the bearing applications are in the range where the copper alloys best satisfy the requirements.

Table 3—Bearing Properties of the Copper Alloys

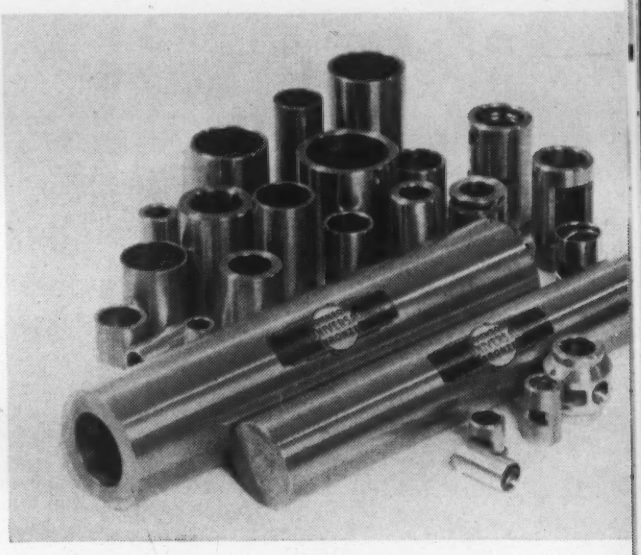
	Copper-Lead	Leaded-Bronze	Tin-Bronze
Load Capacity	Moderate	High	High
Speed	Moderate	Low	Low
Seatability	Good	Fair	Fair
Seizure Resistance	Good	Fair	Poor
Embeddability	Good	Fair	Poor
Corrosion Resistance	Poor	Fair	Good
Fatigue Resistance	Fair	Good	Good

A listing of comparative bearing properties is given in Table 3 for the three classes of copper bearing alloys. In Table 1, the high load alloys are at the top of the table and the high speed alloys at the bottom. There is not a great difference between any alloy and the next one below it in the table in terms of bearing properties. If a given alloy is satisfactory the alloys below it will be used for applications at higher speeds, lower loads and where it is desirable for the alloy to embed dirt and conform more readily.

The high load alloys are used for heavy duty loads at low speeds in such applications as roll neck bearings for rolling mills, lathe bearings, piston pin bushings, valve guides and levers. In an application such as a piston pin bushing in a large Diesel engine, the load based on projected area may be 10,000 psi. With good lubrication and the relatively small rocking motion the 80-10-10 alloy will give good service when used with a hardened pin. Clearance for such an application may be 0.0005 in. per in. of shaft diameter.

The leaded bronzes are used for intermediate loads and general purpose applications. They are used for light duty machinery, fractional horsepower electric motors, home appliances, farm machinery, pumps, thrust washers and cable drum bearings for lift machines. In a typical electric motor application the load may be 100 psi, the surface speed 250 ft per min and the clearance 0.001 in. per in. of shaft diameter.

The copper leads are used at moderate loads and speeds for small internal combustion engines and large internal combustion engines for main and connecting rod bearings, but not for the heavy duty automotive engines. They are also used for many miscellaneous applications in this same load range, such as for large electric motors, turbines and steam engines. The general application range may include loads of 200 to 1000 psi, speeds of 200 to 800 ft per min and clearances of 0.0005 to 0.002 in. per in. of shaft diameter.



Solid and cored bronze bearing stock, general purpose and replacement bushings.

No particular bearing material, structure or design can be recommended for general application to a field of products, such as electrical motors or internal combustion engines. Many alloys and types of bearings will be found in each field. To select a bearing material it is necessary to start with the unit, and consider speed, load, clearance, temperature, dirt, alignment, viscosity of the oil, method of lubrication, length of the bearing, shaft deflection, cold starting conditions, shaft finish and shaft hardness. Many tables and formulas exist in engineering literature to estimate the limiting conditions, but for the most practical cases, the decision is made on a basis of similar usage and bearing acceptance tests in the specific equipment. For a great many applications where conditions are not critical, bronze alloys are used merely on a general purpose basis.

Landing gear components for giant aircraft such as 200-passenger Douglas YC-124B, which has gross weight of 200,000 lb, are forged from the new high strength structural steels. These steels are used also in airframe components.

New Super-High Strength Structural Steels

Developed to improve the strength-weight ratio of aircraft components, these steels can be heat treated to strength levels of 200,000 to 300,000 psi.

by A. E. NEHRENBERG,

Supervisor, Research Laboratory, Crucible Steel Company of America

● DURING THE PAST few years a new class of steels has been developed which is designed to be quenched and tempered to high strength levels. These steels, developed for use in aircraft landing gear and airframe components are different from the high-strength low-alloy structural steels which have been used in the hot rolled or normalized condition for many years in structures which are so large that heat treatment is impossible.

The new steels, having compositions conducive to deep hardening can be through-hardened in any size up to 4 in. in diameter and possess superior toughness when heat treated to strengths above 200,000 psi. They were developed as a result of the constant search by the aircraft designer for the strongest materials of the lightest weight.

Comparison of High Strength and Super High-Strength Steels

Material	Composition, %	Heat Treatment	Yield Strength, 0.2% offset, psi	Tensile Strength, psi	Elong, % (2 in.)	Red. of Area, %	Rockwell Hardness	Izod Impact Value V-Notch, ft-lb	
								70 F	−40 F
SAE 4340	0.40 C, 0.65 Mn, 0.30 Si, 0.80 Cr, 1.80 Ni, 0.25 Mo	—	174,000 212,000	180,000 236,000	14 10	45 35	— —	35 15	— —
HY-Tuf	0.25 C, 1.35 Mn, 1.50 Si, 1.80 Ni, 0.25 Cr, 0.40 Mo	Oil quenched from 1600 F, tempered at 550 F	190,000	230,000	13	49	C46	30	25
Super HY-Tuf	0.40 C, 1.30 Mn, 2.30 Si, 1.40 Cr, 0.20 V, 0.35 Mo	Oil quenched from 1700 F, tempered at 550 F	241,000	294,000	10	35	C54	14	11
High Carbon Super HY-Tuf	0.47 C, 1.28 Mn, 2.42 Si, 1.11 Cr, 0.25 V, 0.42 Mo	Oil quenched from 1700 F, tempered 4 hr at 500 F	—	325,000	—	24	—	9.5	—

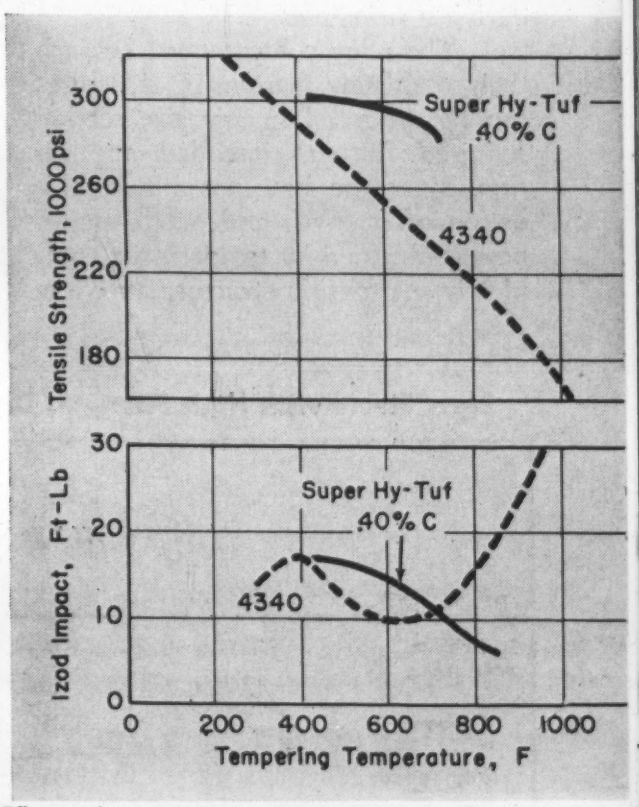
Ten years ago the strongest yet lightest material available for aircraft structure was 24S aluminum. This alloy having a tensile strength of about 60,000 psi was preferred at that time for the airframe. In the landing gear where steel with its higher elastic modulus is preferred, SAE 4340, heat treated to about 180,000 psi tensile strength was used. Since steel weighs about 3 times as much as 24S, steel having a tensile strength of 180,000 psi has the same load carrying capacity as 24S which has a tensile strength of 60,000 psi.

During the last 10 years 75S aluminum became available and this alloy, which is 16% stronger but weighs no more than 24S, has now been adopted for airframe construction. The steel landing gear designed to have a tensile strength of 180,000 psi is no longer equal in load carrying capacity to the new aluminum airframe. The tensile strength of 75S is about 70,000 psi and a steel landing gear would have to be designed with a tensile strength of 210,000 psi to be as efficient. The conventional nickel-chromium-molybdenum steel, SAE 4340, can be readily heat treated to the 210,000 psi tensile strength level, but the increase in strength is accompanied by a definite lowering of the ductility and impact resistance. Increasing the tensile strength from 180,000 to 210,000 psi results in a reduction of the Izod impact value from 35 to about 15 ft-lb. Similar properties were found in a large number of existing steels. Inasmuch as the aircraft designers seemed reluctant to use steel having an Izod value much lower than that corresponding with the 180,000 psi tensile strength level, it seemed necessary to determine if a steel could be developed which would have 30 to 40 ft-lb Izod at a higher level of tensile strength.

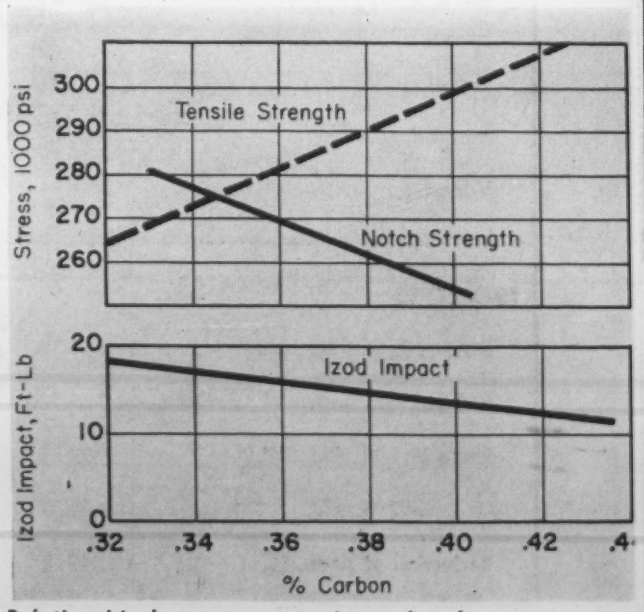
High Strength Steels

These considerations led to the development of a 0.25% carbon-high silicon steel containing balanced amounts of nickel, chromium, molybdenum and manganese. The steel, designated HY-Tuf, met the requirement that it have the same ductility and toughness at 230,000 psi as SAE 4340 has at 180,000 psi. Extensive investigation of the effect of notches on ductility showed that this steel and others developed for the same purpose are clearly superior to such alloy steels as 4340, 4140, 3140 when the comparison is made on steels heat treated to strength levels above 200,000 psi.

We have only a meager amount of information concerning the properties of the competitive steels, but preliminary indications are that their properties are generally of about the same order of magnitude as those of HY-Tuf. The accompanying table shows the results of tensile tests made by an independent laboratory on three of the new super high strength steels. The composition designated B-514 was developed by U. S. Steel Co. and the Cr-Ni-Mo-V steel is a development of Republic Steel Corp. Note that the carbon content of each of the super high strength



Effect of tempering temperature on the Mechanical Properties of 4340 and Super HY-Tuf.



Relationship between properties and carbon content of Super HY-Tuf.

steels is only 0.25 to 0.30%. This is highly significant. The last column in the table contains the properties of SAE 4340 heat treated to two levels, 180,000 psi tensile strength and 236,000 psi tensile strength whereas that shown for the Cr-Ni-Mo-V steel is somewhat lower. The elongation value shown for B-514 is indicated to be for a 1-in. gage length and is low if taken at its face value. It is likely, however, that the 14% elongation for B-514 is for a 2-in. gage section, and if so, this steel also meets the elongation requirement.

The first experimental landing gear forgings of HY-Tuf were installed about 5 years ago and its use in this application has shown a steady increase.

Further development was expedited by the discovery of certain underlying principles.

1. The alloy content must be such that completely martensitic structures can be produced in any size section required for the intended application, since the best possible combination of strength and notch toughness is obtained by tempering a completely martensitic structure at a low tempering temperature to a high hardness level.

2. The carbon content must be as low as possible to obtain the required strength level after heat treatment. The older high strength steels such as 4340 contain 0.40% carbon and because of this higher carbon content are not so resistant to notch impact at the 230,000 psi tensile strength level as the new steels with their lower carbon content.

3. The peak in the impact tempering temperature curve should be raised to the highest possible temperature by the addition of silicon or some other element which has this effect.

Super High Strength Steels

After the successful development of HY-Tuf, the aircraft industry asked for a steel which could be heat treated to 300,000 psi tensile strength and which, in this condition, would have impact properties similar to those of HY-Tuf at 230,000 psi tensile strength.

The principles discussed previously were used in an attempt to come as close as possible to the specified requirements. The carbon content was kept as low as possible, silicon was added to suppress the cementite reaction and the alloy content was balanced to obtain the required hardenability. The result was Super HY-Tuf, a new 300,000 psi tensile strength steel.

The analysis shown in the table is considered to be optimum for this grade with the exception that silicon should be about 2.0 rather than 2.3%.

It is noteworthy that no strategic alloy is added to this steel. In the development work it was found that nickel need not be present to obtain good low temperature properties.

When heat treated to 294,000 psi tensile strength the new steel has a room temperature V-notch Charpy value of 14 ft.-lb. At —40 F the Charpy value is 11 ft lb. The elongation in 2 in. is 10% and the reduction of area 35%. These properties appear to be typical for a 300,000 psi tensile strength steel. We have obtained comparable properties for several other heats and were unable to obtain consistently higher toughness or ductility in any of the large number of experimental steels tested during the course of this development.

When the best possible combination of toughness or ductility and high tensile strength are desired, it is thought best to employ a temper at the temperature corresponding with the end of the first stage of tempering. The strength level can be varied by varying the carbon content up to about 0.50% max. The relationship between carbon content and tensile strength for Super HY-Tuf austenitized at 1700 F, oil quenched and tempered at 550 F is shown in a graph. After this heat treatment the tensile strength increases at the rate of about 5000 psi for each increase of 0.01% in carbon content.

Since it is not practical to control the carbon content in commercial heats within a range less than about 0.05%, the tensile strength would be subject to a total variation of about 25,000 psi. For example, melting limits for the 300,000 psi tensile strength requirement have been established as 0.38 to 0.43% carbon. The tensile strength corresponding with this variation in carbon content will range from about 290,000 to 315,000 psi.

There has been some interest in the lower tensile strength level of 270,000 psi. This requires a some-

New Steels with High Strength, Ductility and Toughness (Schapiro)[e]

	HY-Tuf[a]	B-514[b]	Cr-Ni-Mo-V Type 2[c]	S.A.E. 4340 (Datum)	
ANALYSIS, %					
Carbon	0.25	0.25	0.30	0.40	
Manganese	1.35	0.80	0.90	0.65	
Silicon	1.50	0.60	—	0.30	
Copper	—	0.70	—	—	
Chromium	—	0.70	0.75	0.80	
Nickel	2.00	2.30	1.85	1.80	
Molybdenum	0.40	0.55	0.45	0.25	
Vanadium	—	—	0.10	—	
PROPERTIES					
Ult Str, Ps	235,500	228,700	247,500	180,000	236,500
Yld Str, Psi[d]	196,700	184,100	222,000	174,000	212,000
Elong in 1 in., %	23.5	14.0	—	23.4	—
in 2 in., %	14.0	—	12.0	14.0	10.0
Reduction of Area, %	49.2	54.8	47.8	45.0	35.0

NOTES:
[a] *Made by Crucible Steel Co.*
[b] *Made by U. S. Steel Co.*
[c] *Made by Republic Steel Corp.*
[d] *Psi for 0.2% offset.*
[e] *Metal Progress, April 1951.*

what lower level of carbon, that is, a range from about 0.32 to 0.37%. The tensile strength associated with this range of carbon content would vary from about 260,000 to 285,000 psi.

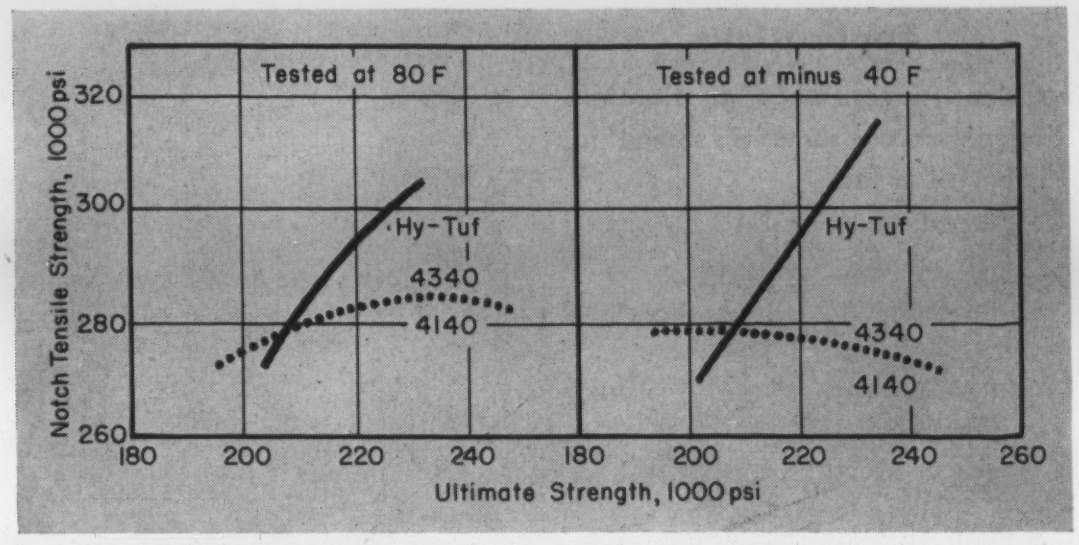
The Izod values decrease linearly with increasing carbon content from about 20 ft-lb for 0.30% carbon to 10 ft-lb for 0.44% carbon. The notch tensile strength also decreases with increasing carbon content and becomes less than the tensile strength when the carbon content exceeds about 0.34%. It does not appear likely, at least at the moment, that it will be possible to obtain much greater notch toughness in steels at these extremely high strength levels and the designer is faced with the necessity of working out the best compromise between strength and notch toughness.

The impact properties of Super HY-Tuf and 4340 at two different strength levels, 270,000 and 300,000 psi tensile strength are compared in a graph. At the 270,000 psi strength level, Super HY-Tuf is clearly superior to 4340 in notch impact resistance. At the 300,000 psi strength level, on the other hand, the two materials are about equal in notch impact properties. Although 4340 contains nickel while Super HY-Tuf does not, the low temperature impact properties of 4340 are no better than those of Super HY-Tuf.

Two other steels which have been proposed for use at this high strength level are designated TN-2 and 98-BV40. Their compositions are given below:

Composition of TN-2 and 98BV 40

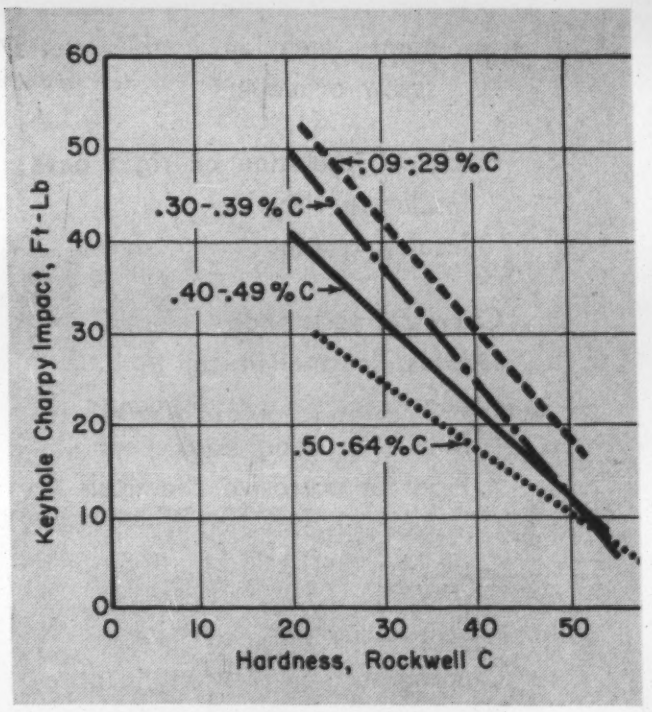
	Super TN-2	98BV40
Carbon	0.38–0.43	0.40–0.45
Manganese	0.70–1.00	0.75–1.00
Silicon	0.50–0.70	0.40–0.70
Chromium	1.30–1.60	0.80–1.05
Nickel	2.00–2.40	0.60–0.90
Molybdenum	0.40–0.60	0.45–0.60
Vanadium	—	aim 0.06
Boron	—	aim 0.0015



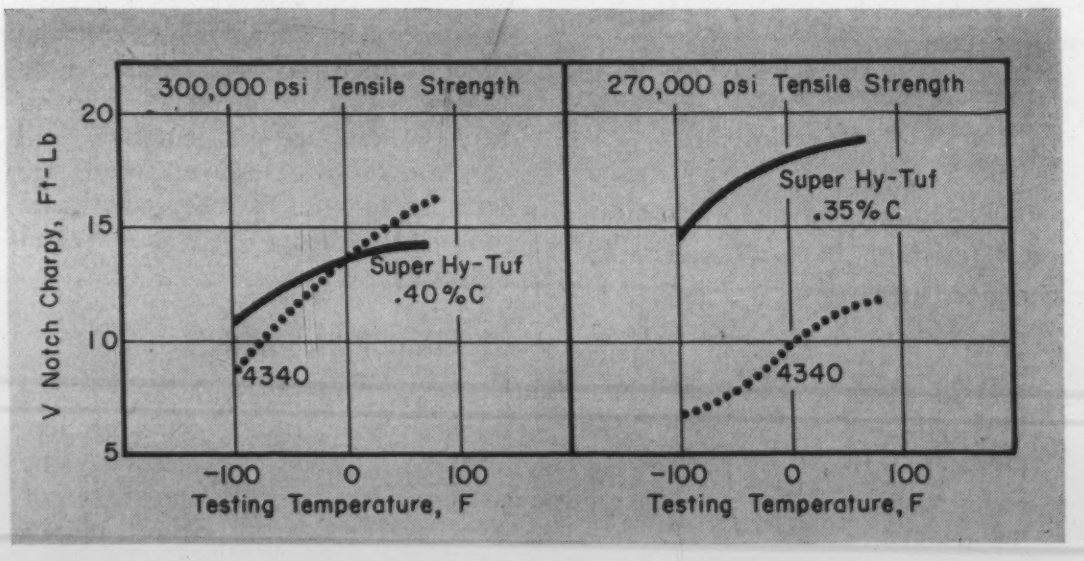
Notched tensile strengths of steels heat treated to high strength levels.

strength steels. These data indicate that the fatigue strengths of Super HY-Tuf and 4340 heat treated to this strength level are no greater either for notched or unnotched specimens over the range from 10,000 to 100,000 cycles than for HY-Tuf heat treated to 240,000 psi. Thus, when a fatigue failure is anticipated, it appears likely that the 300,000 psi tensile strength steel would perform no better than a 240,000 psi tensile strength steel.

The tensile strength of Super HY-Tuf can be increased above the 300,000 psi level by increasing the carbon content. When the carbon is 0.45% the tensile strength after a 550 F temper is 320,000 psi and the Izod value is 11 ft-lb. A further increase in carbon to 0.49% increases the tensile strength to 330,000 psi and decreases the Izod value to 8 ft-lb. It is not clear what the limiting Izod value should be. The 75S aluminum alloy has performed satisfactorily although its Izod value is less than 5 ft-lb. Whether the same value will assure adequate toughness for steel structures remains to be established.



Impact strength of steels in relation to the carbon content and hardness level.



Relationship between impact strength and temperature for Super HY-Tuf and 4340 at two strength levels.

Some fatigue data have been obtained for the new 300,000 psi tensile

Applications

Oxidation resistance at elevated temperatures, some resistance to chemical attack

- Airplane engine parts
- Flue linings
- Space heaters
- Hoods, Stove linings
- High - temperature processing equipment
- Furnace parts

Smooth abrasion resistant surface, low coefficient of friction

- Bearings
- Material - transporting equipment, such as coal shutes, screw conveyers

Electrical insulation on rigid base

- Insulating rings
- Insulating pins

Chemical resistance

- Glass-lined chemical tanks
- Beer processing equipment
- Milk processing equipment
- Pipe for corrosive chemicals
- Valves subjected to corrosion
- Linings for hot water heaters
- Pump parts

Colored surface resistant to abrasion and mild chemical attack

- Decorations in jewelry
- Dishes
- Ash trays
- Interior architectural uses
- Automobile emblems

Weather resistance plus a pleasing appearance

- Signs
- Exterior architectural uses

Easily cleaned, usually white, surface resistant to heat and mild chemical attack

- Kitchen utensils
- Electrical appliances
- Gas appliances for household
- Hospital ware
- Reflectors
- Show cases
- Commercial refrigeration
- Stoves

***CONVEYING BUCKETS** used for carrying abrasive material have longer life with abrasion resistant ceramic coatings. (Porcelain Enamel Institute)*

***PUMP PARTS** for use with highly corrosive liquids are lined with ceramic coatings.*

← These applications take advantage of the

● THOSE CERAMIC COATINGS which are thin layers of glass or which are composed of crystalline materials in a glass matrix, are usually called vitreous enamels, porcelain enamels or glass linings. The latter term is reserved for coatings which are highly resistant to chemical attack, while less glassy types are often called refractory coatings because the crystalline materials added make them more heat resistant. All of these can be designated by the more general term "ceramic coatings".

Ceramic coatings are hard, scratch resistant, withstand a reasonable degree of thermal shock, and can be heated without damage at temperatures where organic materials will char or burn. However, there are other properties whose values are only now being recognized and utilized.

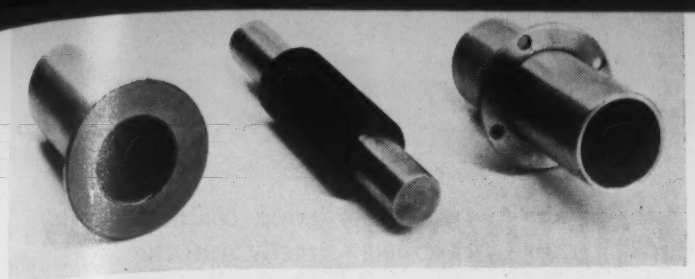
Preparation of Coatings

Ceramic coatings can be applied to metal parts readily on a production basis. The constituents of the coatings are mainly powders of glass and refractory oxides plus a suspending agent, such as clay. These are milled together in water and the suspension, or slip, is then applied on the previously formed metal shape by dipping or spraying. After drying, the coated piece is fired at temperatures ranging from 1000 to 2000 F for a period of from three minutes to an hour, depending on the nature of the coating and thickness of the metal base.

The relative thermal expansion of the coating and the metal is important, but ordinarily not extremely critical. Usually, it is desirable to have the coating in compression when the fabricated article is at room temperature. The optimum amount of compression depends on the thickness of the coating and of the metal base. The closest match in expansion of the two materials is required when the coating and the metal are both heavy. Coatings around 5 to 15 mils thick usually have a thermal expansion of about four-fifths that of the metal base. Of course, thermal expansion is a serious problem when the metal has an appreciable volume change in the temperature range where the coating is rigid.

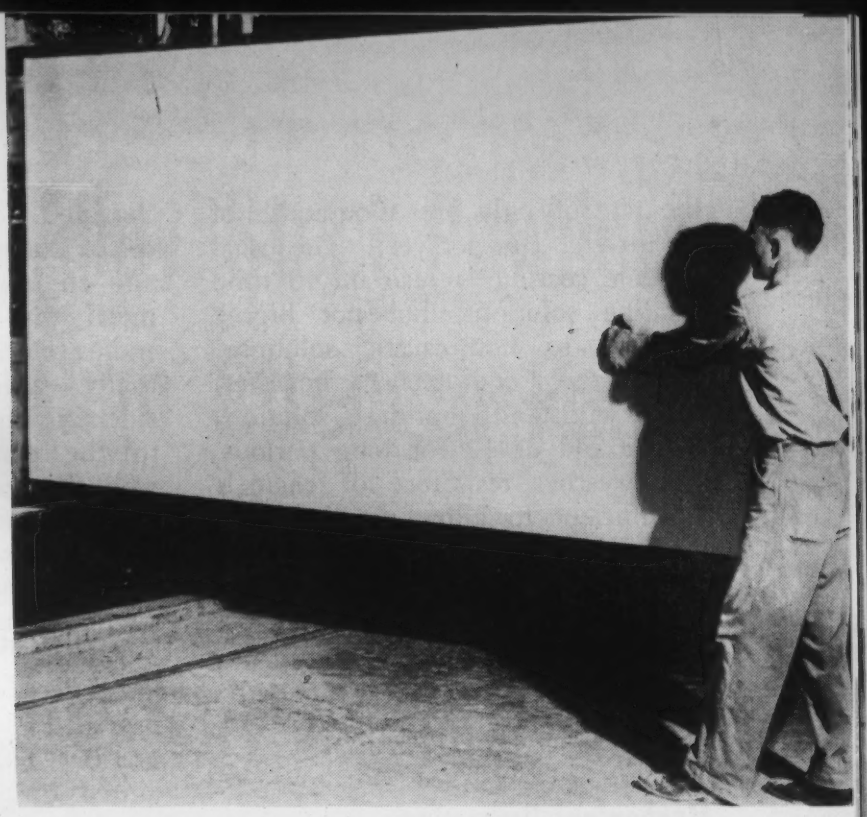
Chemical Resistance

Generally, the more chemically resistant glasses are the more re-



BEARINGS with ceramic coatings have smooth, abrasion resistant surfaces and low coefficient of friction.

CERAMIC COATED PIPE resists molten aluminum and is used in aluminum purification.



COATED PANELS, after drying, are fired at temperatures ranging from 1000 to 2000 F. (All photos, except as indicated, from Barrows Porcelain Enamel Co.)

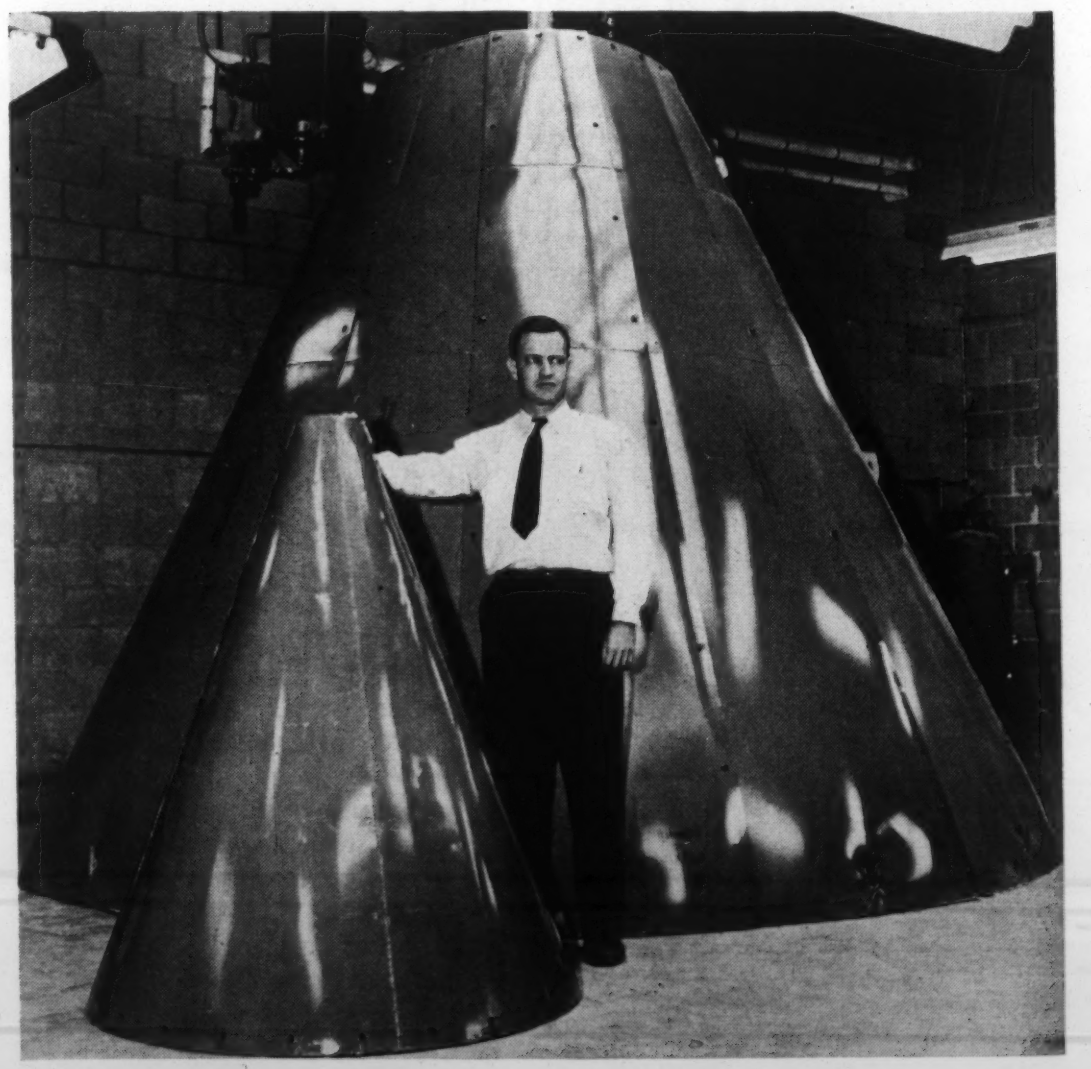
Properties of Ceramic-Coated Metals

by **BURNHAM W. KING,** Consultant, Battelle Memorial Institute

fractory ones. For best chemical resistance, therefore, firing the coatings at as high a temperature as possible is desirable. Unfortunately, the properties of the metal limit the maximum temperature which can be employed. The steel used for most enameling starts to deform at around 1650 F. Heavy-gage stock can be heated somewhat higher, but lighter gages will deform badly unless carefully supported. The result is that most commercial enameling is done at 1550 F or below.

In the dry-process enameling of cast iron, the ware is heated to a somewhat higher temperature, but the nature of the application process requires that the enamel be very fluid at enameling temperatures. Also, the compositions are made more fusible than those usually used on sheet steel. In spite of this limitation a high degree of chemical resistance is obtained.

Regular commercial enamels are sufficiently resistant to be unstained by fruit acid and to be attacked only slowly by boiling in most of the common acids. Special coatings for chemical equipment, glass linings, are extremely resistant to these boiling acids, and are attacked at



JET ENGINE TAIL CONES, furnace hoods, and high temperature processing equipment use ceramic coated metals for their oxidation resistance at elevated temperatures.

the rate of only one thousandth of an inch or less per year. The usual ceramic coating is resistant to mild alkaline solutions, but not highly resistant to hot caustic solutions. Glass-lined equipment, however, will withstand boiling solutions with a pH of 12 for long periods. The weather resistance of enamels is sufficient to allow excellent service on the exterior of buildings and seven-year tests by the National Bureau of Standards show almost no attack on acid-resistant-type enamels, except in areas where the atmosphere was exceptionally corrosive.

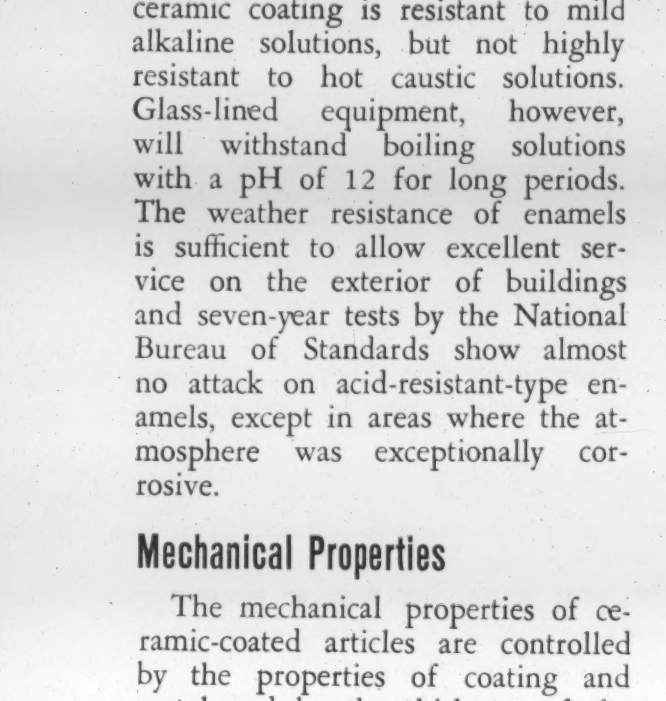
Mechanical Properties

The mechanical properties of ceramic-coated articles are controlled by the properties of coating and metal and by the thickness of the two materials. The properties of a ceramic coating can be varied somewhat by changes in formulation, but all ceramic coatings contain a high percentage of glass, a brittle material which behaves accordingly. To obtain an article which will withstand mechanical abuse, it is usually desirable to apply the coating as thinly as possible and to use a relatively heavy metal base. At present, coatings only one mil thick are sometimes used commercially, but coatings may range from about two to seventy mils depending on type of coating and nature of the metal base.

If both coating and metal are thin, the combination becomes quite flexible. For example, with a porcelain enamel thickness of 1½ mils and an iron of 10 mils, the coated metal can be bent on a 2½-in. radius without enamel failure. Actually, such an enamel adds considerable rigidity, and even strength to the combination. This fact is well illustrated by impact or bending tests on enameled kitchenware. In this case, doubling the enamel thickness may increase the impact strength 10% or more.

Another example of the stiffening effect of porcelain enamels is provided by data presented in a graph. This shows the load required to produce a given amount of deflection in enameled and in uncoated sheet iron. The enamel thickness was estimated by assuming that a porcelain enamel applied at a weight of 5 gm per sq ft. has a thickness of 0.001 in.

These examples illustrate the relative importance of increasing the thickness of enamel or of the metal. Starting with 18, 20, or 26 gage iron, the effect of adding enamel is shown by the solid line, whereas, the effect of increasing the metal thickness is shown by the broken line. Although the density of porcelain enamel is less than one-third that of iron, the stiffening effect of an enamel coating can be three times or more that of an equivalent thickness of iron.



How strength of enameled iron compares with bare metal.

New Developments and Applications

To obtain thin enamel films, only one coat can be applied. This necessitates the elimination of the dark colored ground, or grip coat, which is ordinarily used under white or light-colored coatings to provide adherence to the metal. Considerable effort has been devoted to this problem, especially to the development of a single coating of white enamel. The first commercially successful application of a one-coat white was made by the Westinghouse Electric Corp, using a titanium steel, a nickel dip, and a titanium oxide-bearing cover coat. Interest now centers in accomplishing the same results without using a special steel. The Strong Manufacturing Co. accomplished this successfully using a special method of metal preparation. The quality of the finished ware was good, but the process was somewhat expensive. To date, no entirely satisfactory solution has been announced. In contrast to the white enamels, the refractory-oxide coatings usually are applied directly on the metal and the problem of adherence is not too serious if they are thin.

Enamels or glasses, being composed of oxides, are effective in protecting the base metal from oxidation. By the addition of the more refractory oxides, it is possible to make coatings for special alloys which will withstand temperatures as high as 2300 F. However, for coatings on ordinary cold-rolled steel, the useful temperature limit is from 1200-1400 F. Originally research on high-temperature coatings was aimed at replacing high-temperature alloys containing elements in short supply with coated, more plentiful metals. This protection is provided by an increase of only about 2% in weight. From this work has come the idea that coated metals can serve in other applications where temperature or corrosion is a problem. As an example, we now find coated metal used where resistance to molten metal is required.

The smooth, hard surface of coated metal has been found to provide an excellent bearing material, with a low coefficient of friction and little tendency toward pitting.

Limited use is being made of the good electrical resistance of enamel. Roughly, an enamel will withstand about 1000 v per mil of thickness. However, for general usage, a lower figure is employed. Excellent results in continuous operation have been obtained with potentials of 50 to 100 v per mil. Enameled parts offer the possibility of using stronger and lighter parts, with good electrical resistance even at elevated temperatures.

Some examples of applications in which ceramic-coated metal has been employed successfully are listed in the accompanying box.

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Chromium-Nickel Alloy Steel Powders for High Strength Parts

Pre-alloyed chromium-nickel powders can now be added to low cost reduced iron powders to produce strong and wear resistant products.

by **E. GORDON**, Metal Hydrides Inc., **W. V. Knopp and J. D. Shaw**, S-K-C Associates

Table 1—Powder Properties of Chromium-Nickel Alloy Powders

	80% Chromium 20% Nickel	50% Chromium 50% Nickel
Sieve Analysis		
+100 mesh	0.0%	0.8%
-100 +150	1.8	4.5
-150 +200	2.9	8.9
-200 +270	5.1	11.0
-270 +325	4.6	12.2
-325	85.6	62.6
Apparent Density, g/cc (by Scott Volumeter)	1.87	1.89

Table 2—Primary Powder Additions vs. Alloy Powder Additions

	50% Chromium 50% Nickel		80% Chromium 20% Nickel	
	Primary	Alloy	Primary	Alloy
% Alloy Addition	7.5	7.5	7.5	7.5
Sintered Density, g/cc	6.83	7.10	6.70	6.63
Tensile Strength, psi	63,500	100,800	70,500	105,000
Elongation, % in 1 in.	4.9	4.6	2.9	2.2
Rockwell Hardness	B-75	B-90	B-79	B-98

Electrolytic Iron Powder and 1% Carbon.
Compacting Pressure: 50 tsi.
Sintered in hydrogen 1 hr at 2190 F.

● SMALL AMOUNTS OF PRE-ALLOYED chromium-nickel powders added to iron powders show considerable promise for making high strength structural parts. Previous work established that blends of pre-alloyed chromium-nickel powders and iron powders can be used to make alloy steel compacts having exceptional properties. High tensile strengths and relatively good elongation are consistently obtained without using secondary operations such as coining or infiltration. While in the preliminary work only relatively costly electrolytic iron powder was investigated, it has now been found that a low cost reduced iron powder of low weight loss in hydrogen can also be used. In addition it has been determined that parts made with iron and pre-alloyed chromium-nickel powder are extremely wear resistant.

Powders and Properties

To establish the best powder blends, alloy powder additions from 1.5 to 20% were made to electrolytic iron powder with 1% carbon added. On the basis of economics and optimum physicals, the alloy powder additions found most satisfactory are: 2.5% by weight of 80% chromium-20% nickel, and 7.5% by weight of 50% chromium-50% nickel. The chromium-nickel alloy powders, produced by the hydride process, have low oxide content and the particles have relatively porous, irregular structure. The sieve analysis and apparent density of the two selected alloy powders are given in Table 1.

Table 2 shows the properties ob-

tained by adding these pre-alloyed chromium-nickel powders to electrolytic iron powder as compared to adding the primary metals in the same proportions. It is evident from these results that the pre-alloyed powder additions produce better results.

As pointed out earlier, because of cost it is desirable to substitute reduced iron powder for electrolytic iron powder. Much preliminary work proved that regardless of pre-treatment, the usual weight loss in hydrogen found in most sponge iron or reduced iron powder gave inferior results to electrolytic iron powder. By varying the method of manufacture, one producer can supply a reproducible, low weight loss in hydrogen, iron powder at only slightly added cost.

The weight loss in hydrogen on this powder is on the order of 0.3% and the powder is used without any further treatment. Tests on these powders varying the carbon content from 0.75 to 1.5% showed that maximum tensile strengths were obtained with 1% carbon addition to the 50% chromium-50% nickel alloy, and 1.5% carbon addition to the 80% chromium-20% nickel.

Table 3 lists the properties achieved by adding pre-alloyed chromium-nickel powders to electrolytic and to the special reduced iron powder. From the table it can be seen that compacts made with either of these types of iron powder plus alloy powder additions have strengths substantially higher than those of iron powder alone.

Heat treatment can be used to further improve mechanical properties where the economics of a specific part will allow the additional operation. Table 4 shows the effect of quenching in water and in oil, and tempering at different temperatures. When compacts must be machined, it is necessary to anneal and then reharden after machining. Effects of such annealing and re-heat treating are also given in Table 4.

The structure of parts made of iron and pre-alloyed chromium-nickel powders appears ideal for wear resistance. As the accompanying photomicrographs show, there is a fine dispersion of chromium-nickel particles throughout. Around each of these particles is a martensite area in a fine pearlitic matrix.

Table 3—Properties of Chromium-Nickel Alloy Steel Powder Compacts

(Made with Electrolytic and Reduced Iron Powders)

	Electrolytic Iron Powder			Reduced Iron Powder (0.25% wt loss in H_2)	
	No Alloy Additions	50% Cr 50% Ni Added	80% Cr 20% Ni Added	50% Cr 50% Ni Added	80% Cr 20% Ni Added
% Alloy Addition	—	7.5	2.5	7.5	2.5
% Carbon	1.0	1.0	1.0	1.0	1.5
Sintered Density	7.12	7.10	6.94	6.80	6.79
Tensile Strength, 1000 psi	68.5	100.8	98.8	103.0	107.9
Elongation, % in/in.	4.0	4.6	2.5	2.5	2.5
Rockwell Hardness	B-78	B-90	B-99	B-100	B-97

Compacting Pressure: 50 tsi.
Sintered in dry hydrogen for 1 hr at 2190 F.

Table 4—Heat Treatment of Chromium-Nickel Steel Alloy Compacts

	Ten. Str psi	Elong, % in 1 in.	Rockwell Hardness
Water Quenched from 1550 F	68,600	1.7	C-40
Oil Quenched from 1550 F	81,500	1.7	C-38
Oil Quenched from 1650 F	81,300	1.7	C-39
Water Quenched from 1550 F, Tempered for 1 hr			
at 400 F	123,500	2.4	B-106
at 600 F	117,000	2.0	B-101
at 800 F	107,000	3.0	B-99
Oil Quenched from 1550 F, Tempered for 1 hr			
at 400 F	119,000	2.5	B-107
at 600 F	123,000	2.5	B-104
at 800 F	119,000	2.4	B-102
at 1050 F	98,500	4.5	B-91
Annealed at 1500 F Cooled at 60° F/hr to 1200 F	81,500	3.2	B-88
As re-heat treated: Re-heated to 1500 F, Normal cooling	107,300	2.6	B-101

Electrolytic iron powder (freshly reduced) and 1% carbon with 7.5% addition of 50% chromium-50% nickel alloy powder.
Compacting pressure: 50 tsi.
Sintered in dry hydrogen 1 hr at 2190 F.
Heat treatment in hydrogen atmosphere.

Pressing and Sintering

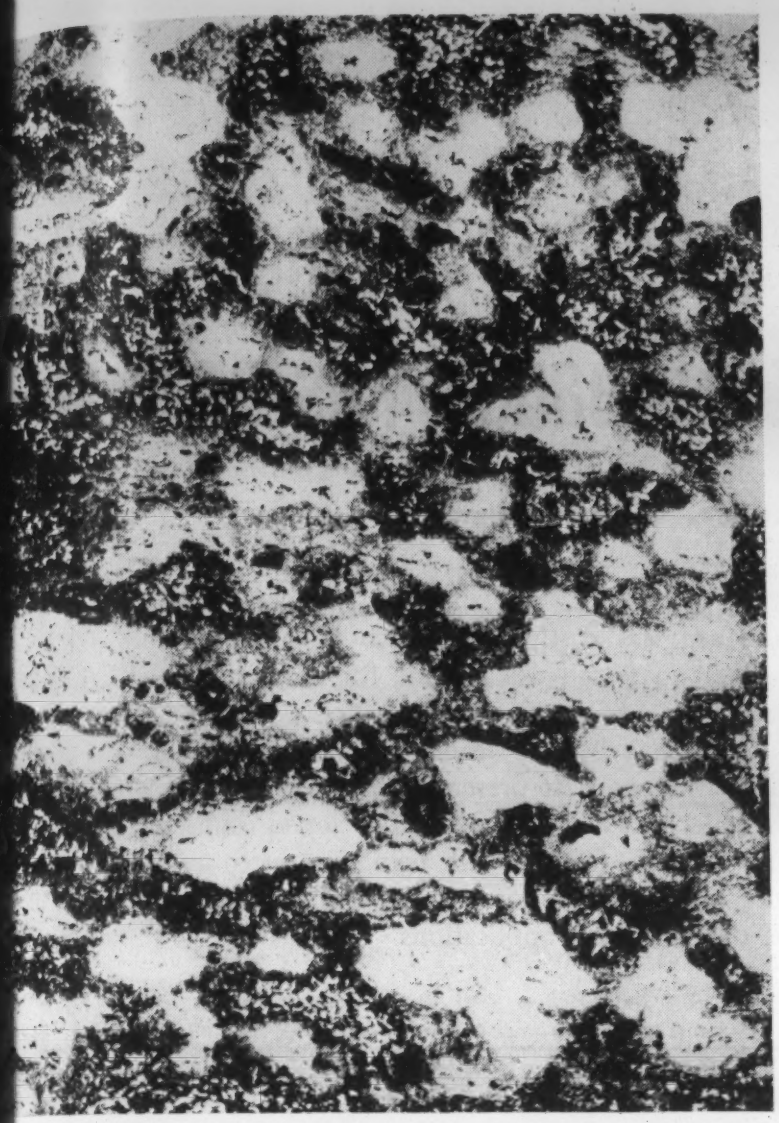
Best practical results are obtained by pressing at 50 tsi and sintering for one hour at 2190 F. In some cases, sintering for two hours at this temperature gives higher strengths, but two hours is considered too long a time for normal commercial practice.

Dry hydrogen is the best atmosphere, but although economically feasible it is relatively expensive compared to other atmospheres. Dissociated ammonia and prepared endothermic gas can also be used for sintering, but lower tensile strength and elongation can be expected as shown in Table 5. Whatever atmosphere is used, it is important that it be dry.

Shrinkage of parts made with these powder combinations is of the same order as for regular iron powder parts. Addition of lubricants to the powders results in compacts having mechanical properties equal to or better than those without lubricants.

Applications

Although the application of chromium-nickel alloy steel powders is still



Photomicrographs of alloy steel powder compacts show fine dispersion of chromium-nickel particles throughout structure. Alloy powder addition is 7.5% of 50% chromium—50% nickel. (Left: 100X; right: 500X)

in its infancy, the properties attainable with them indicate that they will find use for structural parts where high strengths or good wear characteristics are required. Parts that must possess such properties include a wide variety of gears, cams, roller and eccentrics.

Reference

J. Shaw et al, *Precision Metal Molding*, Mar. 1953.

Table 6—Dimensional Changes

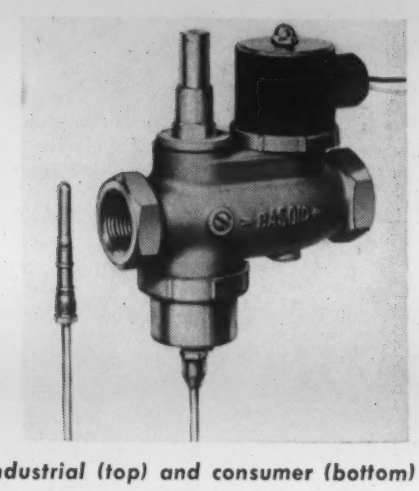
Sintering Temp, F	Change in Length in./in.	
	50% Cr-50% Ni (7.5% Addition)	80% Cr-20% Ni (2.5% Addition)
2010	+0.0015	-0.004
2190	−0.012	-0.009

Electrolytic Iron Powder and 1% Carbon.
Compacting Pressure—50 tsi.
Sintered in Hydrogen 1 hr.

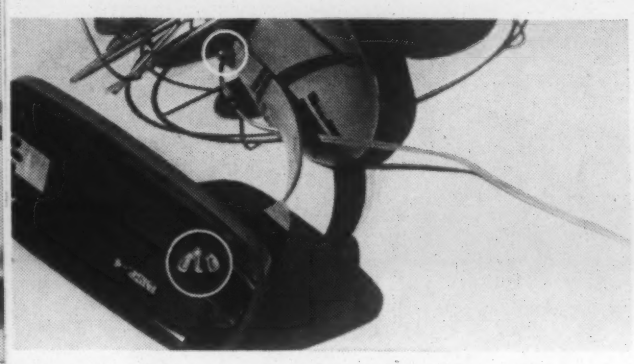
Table 5—Effect of Atmospheres

Atmosphere	Ten. Str psi	Elong, % in 1 in.	Rockwell Hardness	Sintered Dens, g/cc
REDUCED POWDER, 7.5% Addition 50% Cr—50% Ni, 1% Carbon				
Dry Hydrogen	99,000	2.5	B-100	6.84
Dissociated NH_3	89,000	2.5	B-98	6.76
Tank Hydrogen	80,500	2.5	B-89	6.80
Prepared Gas*	70,000	1.5	B-98	6.73
ELECTROLYTIC IRON, 7.5% Addition 50% Cr—50% Ni, 1% Carbon				
Dry Hydrogen	100,800	4.6	B-90	7.10
Dissociated NH_3	95,000	2.5	B-98	6.95
Prepared Gas*	98,200	1.0	B-95	6.91
ELECTROLYTIC IRON, 7.5% Addition 80% Cr—20% Ni, 1% Carbon				
Dry Hydrogen	105,000	2.2	B-98	6.63
Dissociated NH_3	83,200	1.5	B-104	6.66
Prepared Gas*	90,200	1.8	B-100	6.64

**Analysis of Prepared Gas: 19% CO, 40% H_2, 1% CH_4, 40% N_2.*
Compacting Pressure: 50 tsi.
Sintering Conditions: 2190 F for 1 hr.



Both industrial (top) and consumer (bottom) products make good use of zinc fasteners.



Milwaukee Gas Specialty Co.
General Electric Co.

For Low-Cost Joining, Try Zinc

Die Cast Threaded Fasteners

by ERNEST W. HORVICK, American Zinc Institute

For many fastening applications, zinc die cast fasteners provide definite design advantages and are less costly to produce than other types. These advantages have led to an increased use of zinc for industrial threaded fasteners in recent years.

Gries Reproducer Corp. has been a leader in developing zinc die cast fasteners and expanding their use. At present they are producing wing nuts, wing screws, cap nuts, toilet seat nuts and newly developed round head thumb screws and nuts. Some of these fasteners are being produced up to 2 in. in length and 1 oz in weight. They are not only proving satisfactory in established uses, but are also finding many new applications.

Wing Nuts

The wing nut is an established type fastener which has been in use many years. The older methods of producing them include: cold forging from round steel and brass wire, malleable iron and sand casting, and stamping.

Cold forging was the first and most successful of the old methods of making wing nuts. However, the cost of manufacturing by this method is considerably higher than die casting. It involves expensive, complicated die systems and requires a series of eight to ten operations. To produce a new, cold forged blank, die costs of approximately $10,000 are required, whereas with die casting only about $1000 die cost is incurred.

Malleable and sand cast wing nuts are no longer widely used except for really large pieces where they still have a competitive footing. Sand casting has considerable design flexibility, but it is much costlier and does not afford good surface finish quality.

Stamped wing nuts, made from sheet and strip brass or steel, can be produced cheaper than die castings, but are limited by poor appearance and short thread lengths. They present a problem in handling because of burrs, and hence cannot be assembled as fast as other types.

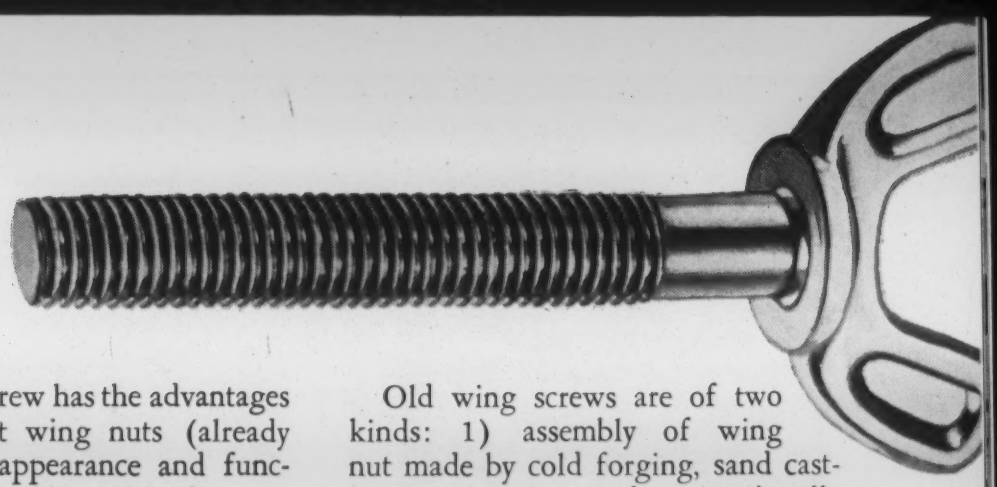
Zinc die cast wing nuts are considerably less expensive to produce for a comparable or better product because of the ease and low cost with which they can be manufactured. In general, they cost about one half as much as brass and 25% less than steel wing nuts made by cold forging or sand casting.

Because of inherent advantages in the die cast process, wing nuts can be made more attractive and functional at no extra cost. For example, the base of the wing can be serrated to act as a locking medium and eliminate use of a lock washer. Also, a recess can be put in the wing to improve appearance and facilitate finger gripping. The improved appearance and functional changes can be introduced at no extra cost because available simple inserts can be put into the die cavities to effect the desired changes. Due to the flexibility of the die cast method, many more styles and designs of cast zinc wing nuts are made than by the other methods.

Zinc die cast wing nuts have good corrosion resistance. Almost all of the competitive wing nuts, except the nonferrous, which are in a minority, have to have a protective finish. The large majority of zinc wing nuts do not have an applied finish. Only those for decorative purposes are given an additional finish.

For outdoor use, wing nuts are employed on TV antennas and these are now all die castings. A zinc die cast wing nut will not freeze on a steel screw in outdoor use. Even though the steel rusts, it will come off readily, if required, thus facilitating assembly and disassembly.

Wing Screws

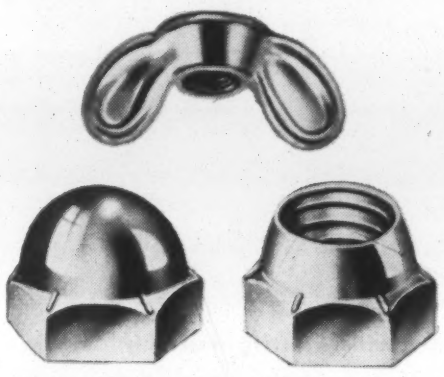


Two new lines of wing screws have been developed as an outgrowth of the wing nut line. There are two types: 1) assembly of die cast body and conventional manufactured screw of steel or brass as shown in the accompanying illustration; 2) all zinc die cast wing screw. This is much less expensive because it is made of one piece, eliminating the assembly operation. The thread is simply rolled on the die cast blank.

This wing screw has the advantages of the die cast wing nuts (already discussed) in appearance and functional design. Also, the die cast method permits varying lengths and diameters of the threaded section by use of simple die inserts. Among numerous applications, die cast wing screws are used on power tools, in the furniture industry, and on automotive and other bracket and clamping devices.

Old wing screws are of two kinds: 1) assembly of wing nut made by cold forging, sand casting or stamping, and conventionally manufactured steel or brass screw; 2) spot weld strip material button wing nut to screw. With both of these, shortcomings of the old production method wing nuts are incurred, in addition to the added assembly or the added spot welding operations.

Threaded Cap Nuts



Cost is the paramount factor in the marketing of threaded cap nuts (also known as acorn nuts). The cost of the zinc die cast cap nuts is considerably lower than the competitive cap nuts of brass which are made out of hex bar stock on screw machines. The cost ratio of the brass stock to zinc is four to one. Added to this is the fact that with the screw machine method, a waste factor of over 50% is incurred.

Steel is used only to a small extent. Even though steel costs only about half that of the zinc, the higher cost of zinc is more than offset by the slow screw machine production rate, without even taking into account losses from the high scrap generation.

The better appearance of die cast cap nuts is another advantage. Attractive ornamentation in the form of ribs can be added. The appearance of cap nuts made by the competitive method is marred by the cut-off nipple and tool marks generated in the turning operation, factors inherent in all screw machine operations.

Material availability is another plus feature in making die cast cap nuts. It has been found much easier to meet unexpected and peak demands because production merely involves going from raw material, zinc ingots, to finished product. Considering the range of hex stock sizes needed to make the screw machine product, it is frequently difficult to get all of these and much time is lost in waiting for specific sizes and types of materials.

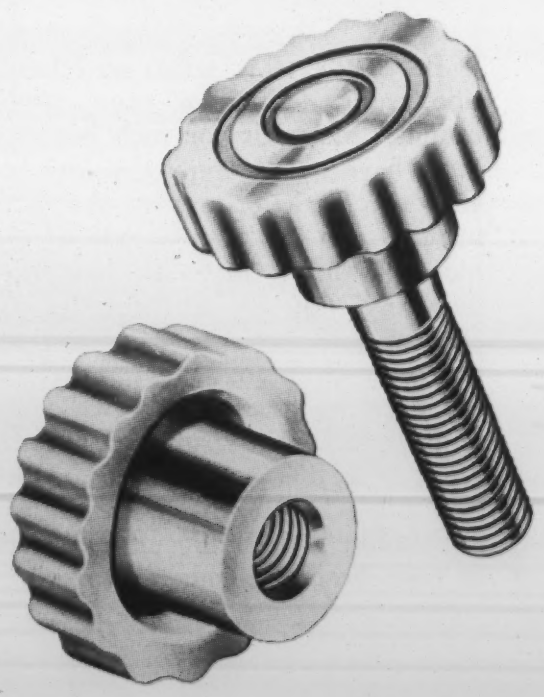
Zinc die cast cap nuts are finding a wide variety of uses for general industrial purposes, such as in tubular furniture, store display fixtures and plumbing.

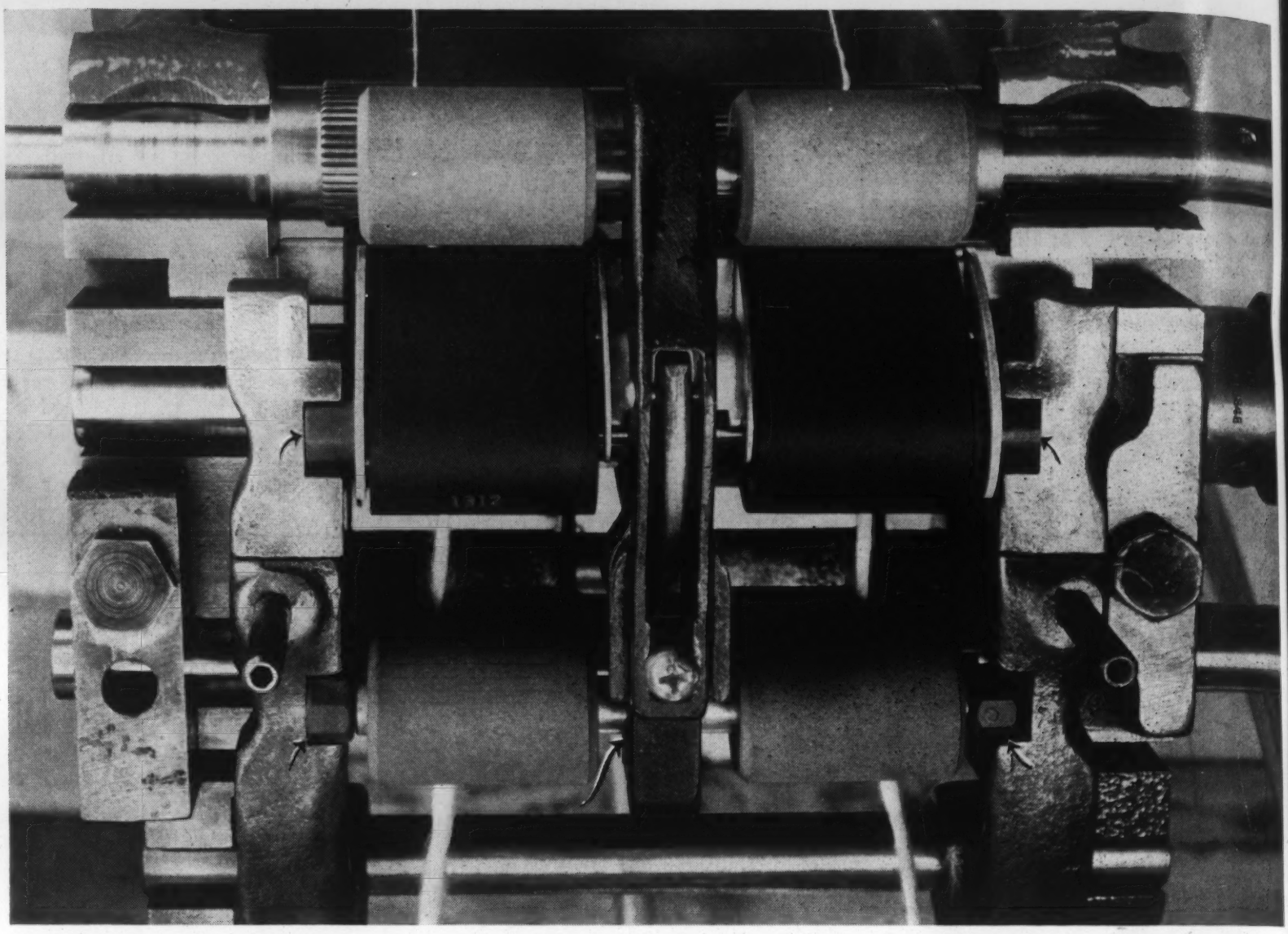
Round Head Thumb Nuts and Screws

Round head thumb nuts and round head thumb screws are new uses for zinc die castings. The advantages of making these of zinc die castings are the same as with cap nuts, plus the fact that they can be made with a very wide thumb grip for good leverage.

Brass knurled head thumb nuts are somewhat akin to these round head thumb nuts and thumb screws. However, the brass pieces are made of round stock, and in order to provide the widest diameter of the finished part, stock of similar diameter must be used. Then in machining to the smaller diameter, for the screw section, much metal is turned off and wasted. Also, only knurling can be done in machining the head to provide a gripping surface, whereas the die cast head is scalloped to assure a better grip.

Die cast round head thumb nuts and thumb screws can be used on the same applications as wing nuts and screws, plus other uses where appearance and over-all height of nut is important. They are especially adaptable in restricted areas where the others cannot be used, e. g. in filing cabinets where limited space does not make possible room for projections.





***SPINNING YARN**—Rulon filled-Teflon bearings were developed to cut maintenance on the Duo-Roth Textile Drafting Assembly. Dry bearings also keep yarn cleaner.*

Filled Teflon for Dry Bearings

Four new compositions have—

Low coefficient of friction
High wear resistance
Chemical inertness
High electrical resistance

by S. RICKLIN, Ricklin Research Associates, and Robert R. Miller, Dixon Corp.

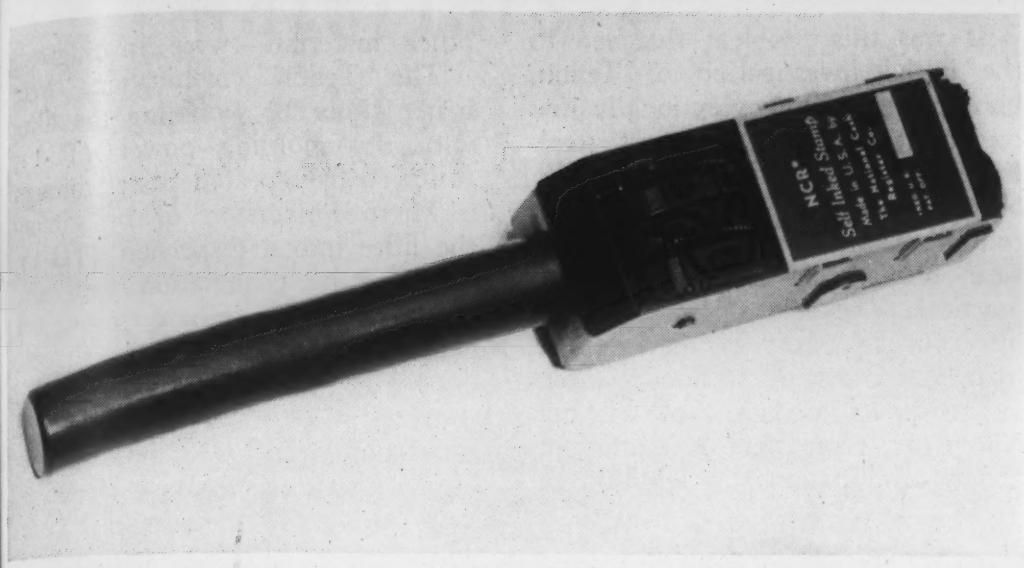
● BEARINGS THAT NEED no lubrication are desirable for many applications. Materials for such bearings must have an exceptionally low coefficient of friction against the shaft material. In this respect, one of the most promising materials has been molded Teflon for which a dry coefficient with steel of as low as 0.04 has been reported. Main drawback has been its excessive rate of wear under practical bearing conditions. Now, with the development of special filled-Teflon materials known as "Rulon", this difficulty appears to have been overcome.

So far, four of these new compositions have been developed. Their friction and wear properties are listed in Table 1 along with those of other materials that have been investigated for unlubricated bearings.

Although the combination of low coefficient of friction and high wear resistance is the most important characteristic of Rulon for most bearing applications, other properties of these materials make them especially suitable for use under severe operating conditions. These properties include chemical inertness, high electrical resistance and low dielectric losses at relatively high temperatures.

Lack of thermal conductivity and high coefficient of thermal expansion make these materials most suitable where rubbing speeds are low or where some provision is made for dissipation of heat. In enclosed sleeve bearings they can be used only with low speeds and light loads. Current research may modify these limitations.

The new bearing materials were developed by the Dixon Corp., Bristol, R. I., particularly for textile



RUBBER STAMP—The ability of Rulon to resist both continued wear and the corrosive action of inks has led to its use in this porous rubber self-inked band stamp made by National Cash Register.

machinery. However, they are also being used for bearings in business machines, mimeograph machines and ice-making machines. Recent applications other than bearings include elevator cams, valve seals, shaft seals, V-rings, etc.

Materials Development

Rulon is the outgrowth of a continuing search by the Dixon Corp. for improved bearing materials to meet special equipment problems. One particularly knotty problem was posed by the saddle bearings on yarn-drawing equipment. These are half-sleeve bearings that run

Friction and Wear Tests

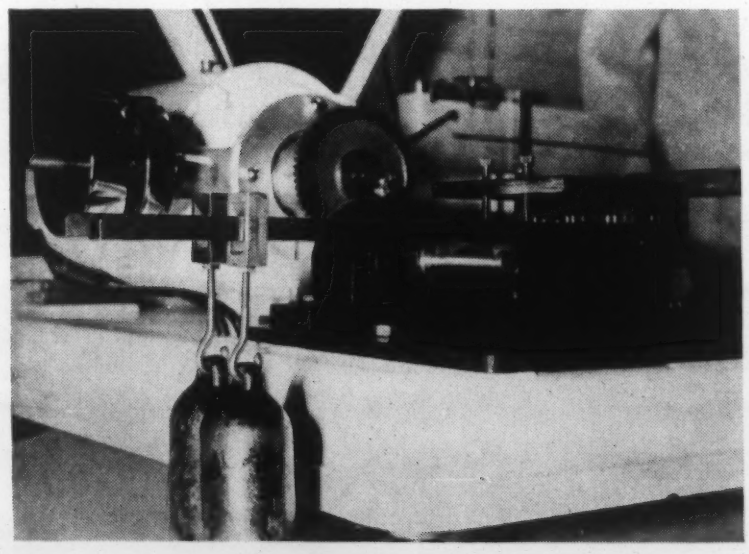
The friction of plastic bearings, particularly when run dry, can be a function of shaft speed; ambient temperature and humidity; load; bearing shape and size; shaft material and surface preparation; time of running; etc. Because of the low thermal conductivity of Teflon, these factors may cause considerable variations in rates of heat generation and dissipation and thus in surface temperature. These changes in temperature affect the physical properties of the material and, consequently, the coefficient of friction. For this reason, it was considered important to obtain friction data from test equipment that duplicated service conditions as closely as possible.

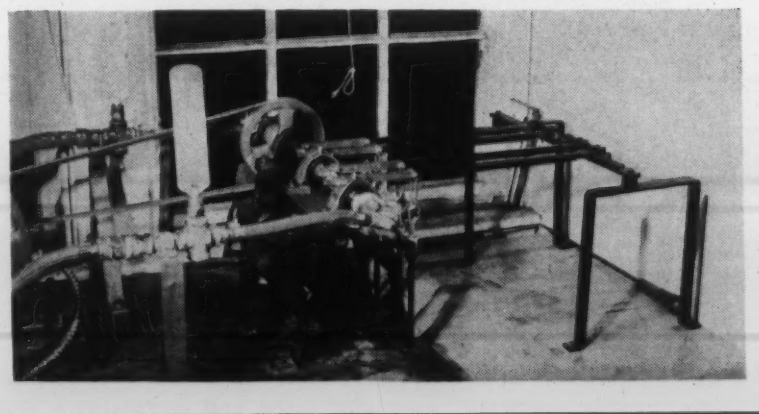
The friction tester used is shown in the photograph (top right). The test bearings were mounted in rods and rode on top of the shaft. The rods were supported at one end by leveling bolts and also acted as loading levers. The testing platform was arranged as a dynamometer and the frictional torque indicated by a recorder. A zero adjustment was used to compensate for friction in the motor bearings. Standard-size bearings were run on a ½-in. shaft of hardened drill rod and under a load of 26.2 psi. The shaft, carefully cleaned before each test, ran at 156 rpm. Ambient temperature was 70 to 75 F. For screening purposes, the torque observed after three hours of running was converted by calculation and reported as coefficient of friction.

In screening a large number of materials on the basis of wear resistance it is necessary to use an accelerated test. Hence, two types of wear testers were used: one was designed for rapid screening and the other, used for the most promising materials, simulated service conditions more closely.

In the preliminary wear tester, some test pellets measuring ⅝ x 3/16 x ⅛ in. were mounted in rods so that their face rested on a 1-in. hardened steel shaft. The rods were loaded as levers to provide a force of 2.9 lb at the contact area. The shaft turned at 425 rpm and was water cooled, an average water temperature of 100 F being maintained. Twenty pellets were run simultaneously, and weight loss and maximum indentation were recorded after various periods of time—usually 24 to 72 hr.

The second wear tester (lower photo), was similar in design but tested four standard-size bearings, rather than pellets, and ran at 800-850 rpm and a bearing load of 120 psi. Weight loss and indentation were measured at intervals of one week (about 8 million revolutions). The indentation measurements were made at nine points with a special fixture and gage, and average and maximum wear in mils per million revolutions were recorded.





against a 9/16-in. cast iron or hardened steel shaft. Bearing load is usually 150-200 psi. The shaft runs at 100-200 rpm, being turned by a roll mounted on it which, itself, is friction-driven by a lower roll. Since the yarn is drawn between the two rolls, it is important that they do not slip against each other, and a bearing with low coefficient of friction is required. A particular installation may have thousands of these bearings so that a bearing needing no lubrication is desirable.

It was this problem that led to the initial investigation of Teflon, known to have an exceptionally low coefficient of friction against steel. Early trials of Teflon in a saddle bearing under appropriate service conditions indicated that its rate of wear was much too high to be practical. The next step was to add fillers in an effort to increase the wear resistance of Teflon without increasing its coefficient of friction. Altogether, more than 200 different Teflon combinations, in addition to other materials, were investigated.

The Teflon combinations were made either by tumbling the filler with dry molding power (TF-1), followed by repeated passes through a Micro Pulverizer, or by stirring the filler into a dispersion (TD-1), followed by coagulation with acetone, filtering and drying. The bearings were pre-formed at about 2000 psi in a hydraulic press and sintered at 650-750 F in a forced convection oven. The most promising materials were also extruded as strip and cut into individual bearings.

The bearings were subjected to both friction and wear tests. Some results of these tests are shown in Table 1. These data are assumed to be valid only for the particular test conditions and were obtained for the purpose of comparing performance of different materials, not for quantitative design. In Table 2, the effect of one variable, the shaft material, is demonstrated.

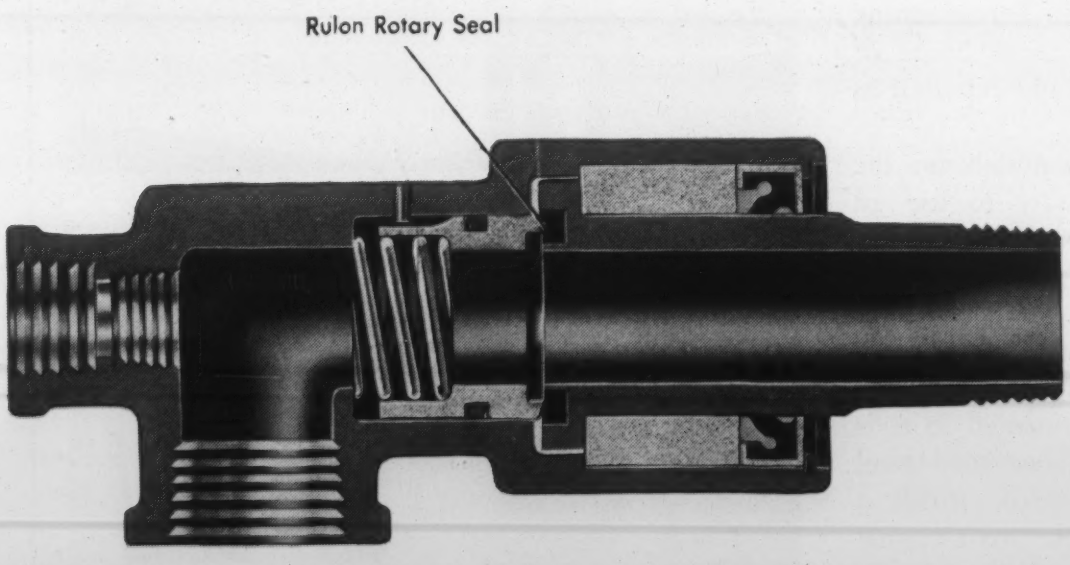
As the data indicate, tremendous improvement in the wear resistance of Teflon, without sacrifice of its low-friction characteristics, can be obtained by adding fillers. Further improvements in bearing materials can be expected when the effects of some of the variables encountered are more fully understood. Studies on the effects of shaft speed, shaft material, bearing pressure, bearing shape and size, molding conditions, etc., are now under way. Already, for example, there is reason to believe that coefficient of friction is relatively independent of bearing pressure up to the point where excessive temperatures develop.

Table 1—Comparative Friction and Wear of Dry Bearings

Bearing Material	Coefficient of Friction		Av. Wear, Mils per million rev. (at 120 psi)
	New	Worn*	
Teflon (TF)**	0.21±0.02	0.26	Too worn to measure
Rulon A**	0.18±0.02	0.22±0.03	0.34±0.15
Rulon B**	0.20±0.02	0.18±0.01	0.17±0.04
Rulon C**	0.17±0.01	0.16±0.01	0.13±0.03
Rulon D**	0.15±0.01	0.17±0.01	0.10±0.04
Nylon FM 1001	0.37±0.01	0.54±0.18	4.2
Nylon plus Aluminum Stearate	0.15	0.24	Too worn to measure
Oil-Impregnated Wood	0.13	0.48	—
Polyethylene	0.73	—	Too worn to measure
Textolite 1835	0.24	0.72	1.1
Textolite 2001	0.24	0.43	0.9
75 Teflon (TD), 25% Glass Fiber	0.26	0.23	0.5
75 Teflon (TD), 25% Mica	0.28	—	0.6
60 Teflon (TD), 20% Glass Fiber, 20% MoS_2	0.17	0.18	0.17
60 Teflon (TF), 40% Aluminum	0.30	—	Too worn to measure
60 Teflon (TF), 40% Bronze	0.27	0.24	0.05
60 Teflon (TF), 40% Lead	0.23	0.25	0.31
15 Teflon (TF), 85% Copper	0.29	0.33	1.0
60 Teflon (TF), 40% Graphite	0.19	0.19	0.77

** Data for standard-size bearings run 3 hr at 156 rpm on new ½-in. hardened drill rod shafts under normal room conditions.*

*** Data are averages based on 5 to 20 pairs of bearings. Data for other materials are based on one pair of bearings.*



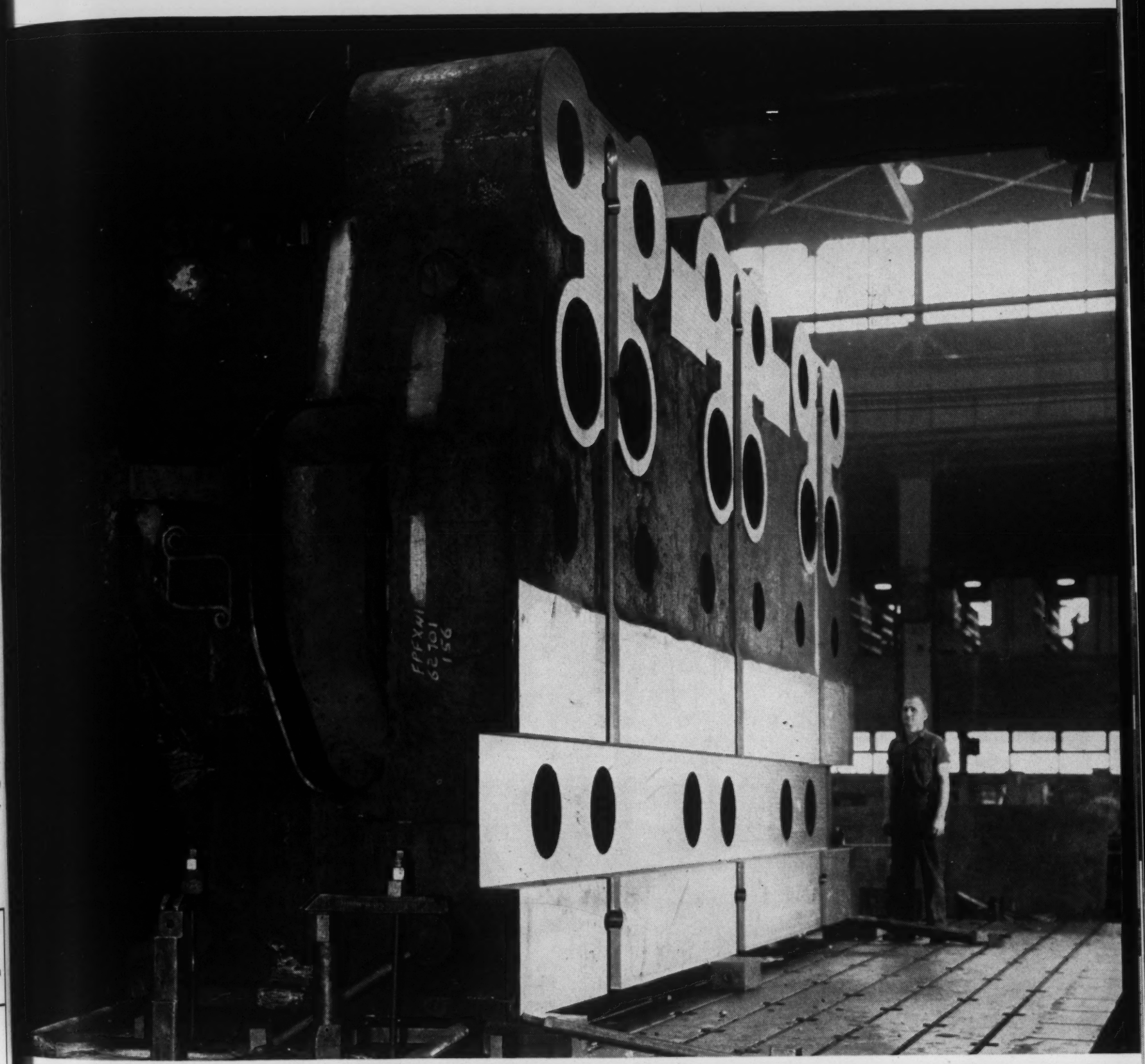
ROTARY SEAL—Rulon replaced the old carbon-type seal in this rotary joint made by Anco, Inc. Costly lapping operations were eliminated and performance was improved.

Table 2—Effect of Shaft Material

Shaft Material	Coefficient of Friction Against Worn Rulon A
Hardened Drill Rod	0.15
Chromium Plated Drill Rod	0.15
Stainless Steel	0.15
Rulon A	0.18
Cast Iron	0.19
Monel	0.24
Cold Rolled Steel	0.32
Brass	0.33

Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .



One-Quarter of Jumbo Steel Forging Press Base This 435,000-lb. steel casting is one of four large castings which will be used in the base of the 35,000-ton forging press United Engineering and Foundry Co. is building for the U. S. Air Force.

This casting, measuring approximately 25 x 13 x 6 ft, is shown being machined on a 15-ft planer at United's New Castle plant.

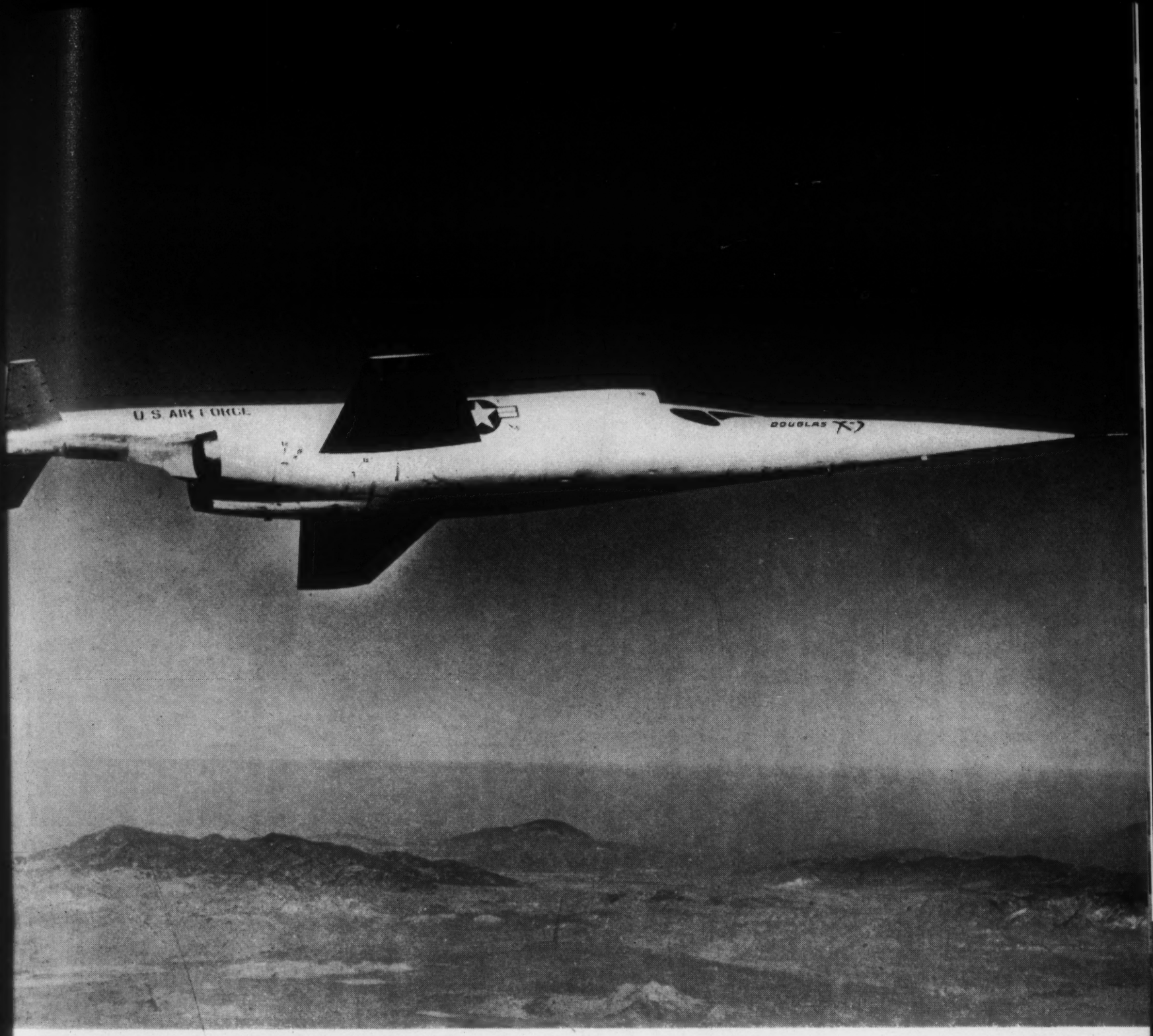
Materials at Work

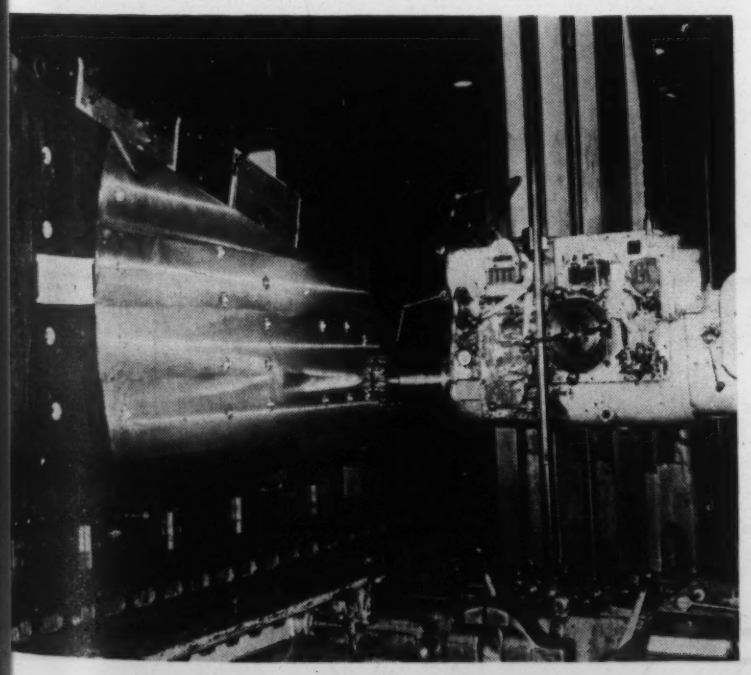
Galvanized Steel After 4 Years

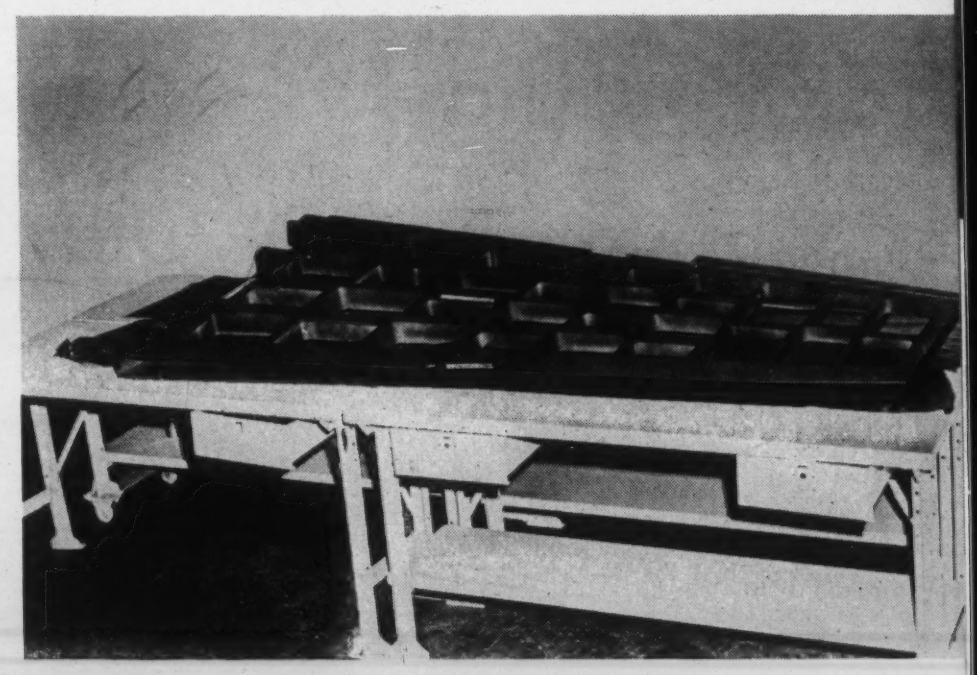
Stainless Steel After 7 Years

When using galvanized corrugated steel for roofing on the building that houses the pig machine at Armco Steel Corp., the roofs had to be replaced every 3 or 4 years. After switching to stainless steel, the roofing is still in good condition after 7 maintenance-free years.

A pig machine consists of a power driven chain conveyor carrying cast molds into which molten iron is poured and chilled into "pigs" of a convenient size for handling. The lime mold wash used to prevent sticking of the hot iron to the molds, was the cause of the accelerated corrosion which led to failure of the galvanized roofing.

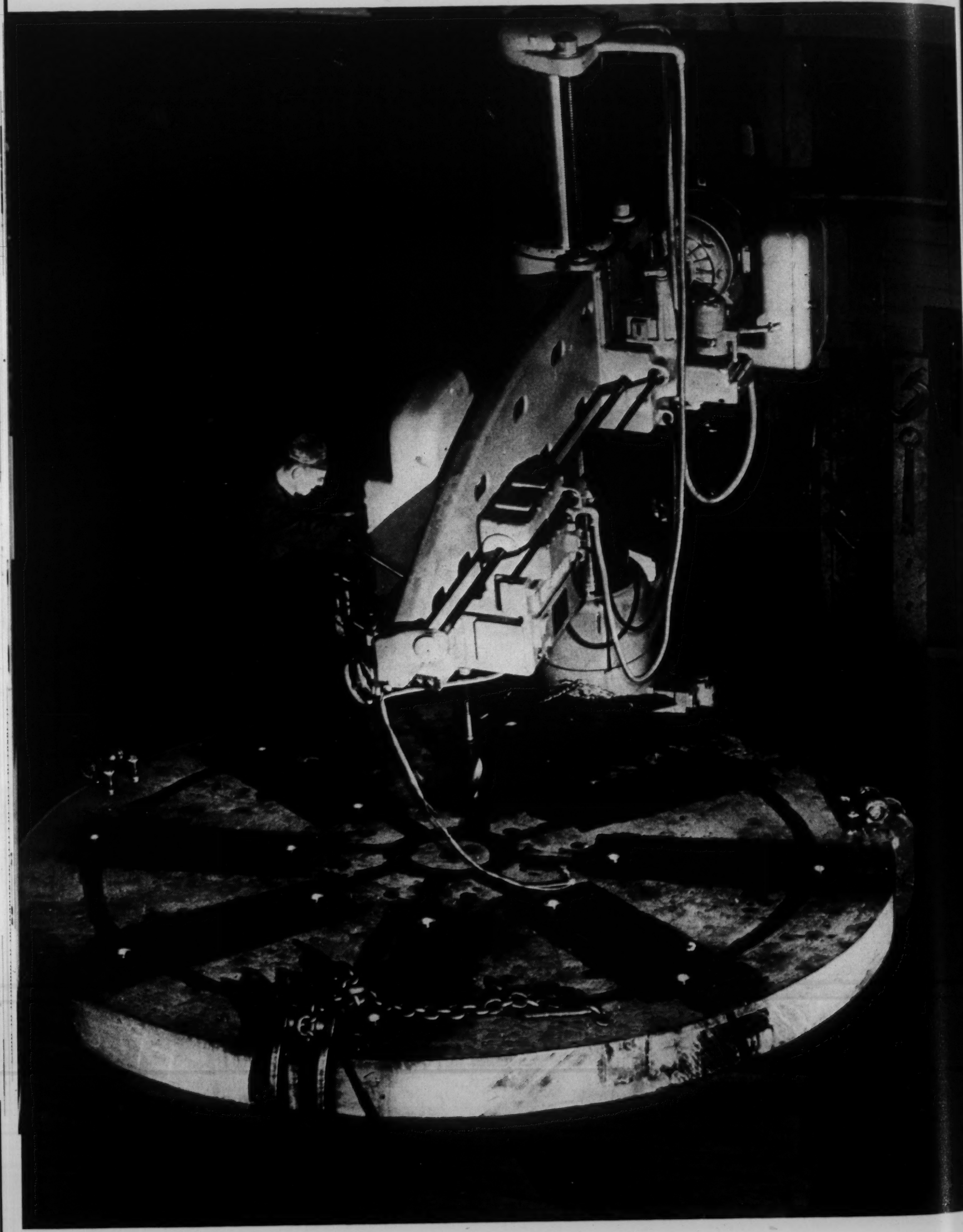


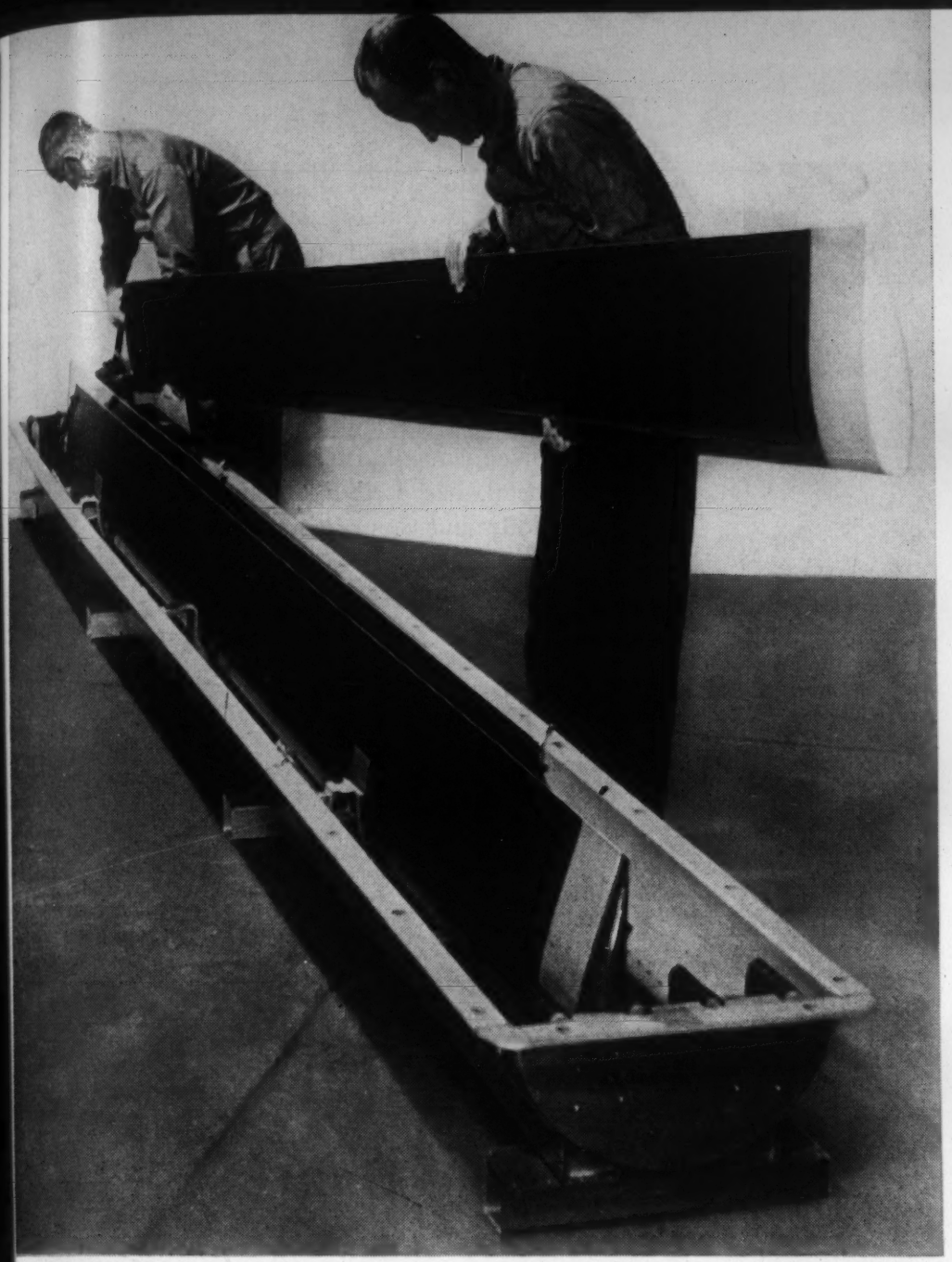




Forged Aluminum Wings For A Stiletto To insure maximum strength in the various directions in which the wing metal is stressed in service, the basic structures of the stubby wings of the Douglas X-3 "Stiletto" were machined from solid 1-ton forgings of 2014 (14S) aluminum. The structures were hand forged by Alcoa and machined to an egg crate pattern and covered with a tapered skin of 2024-T86 (24S-T86) aluminum by Douglas Aircraft Co., Inc. Shown here is primary machining operation and resultant one-piece egg-crate skeleton.

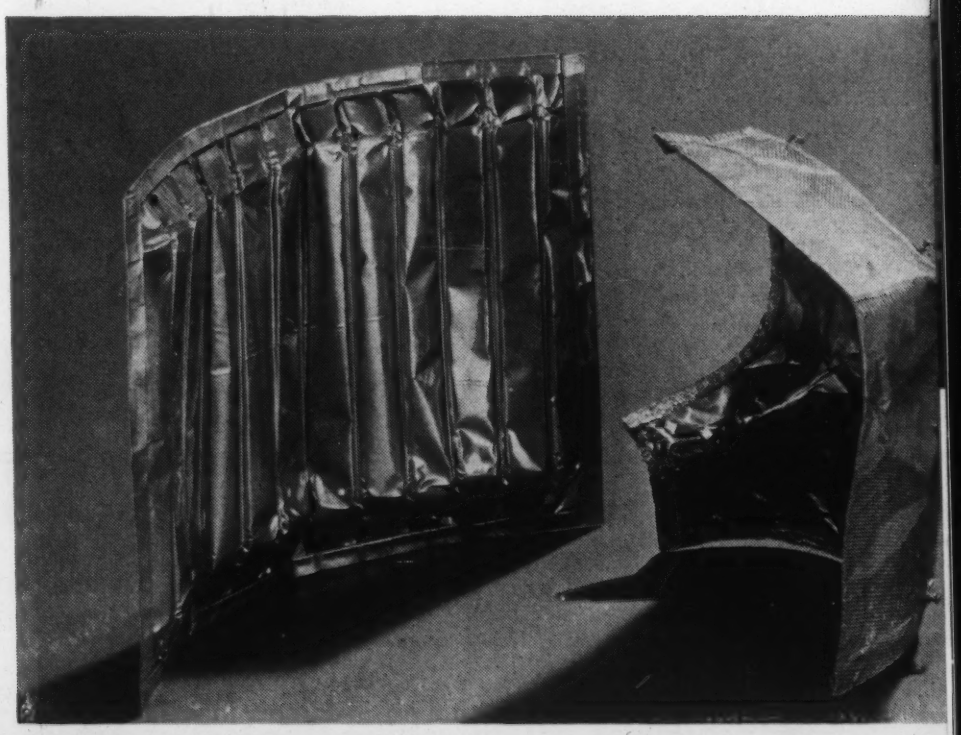
Rolled Steel To Chew Logs This steel disk, 12½ ft in diameter and nearly a foot thick, rolled by Lukens Steel Co., will soon be chopping 150 cords of western hemlock logs an hour for wood pulp. The machine, designed by D. J. Murray Mfg. Co. will have 8 knives and will turn a log 3 ft thick and 20 ft long into a pile of chips in about 10 sec.





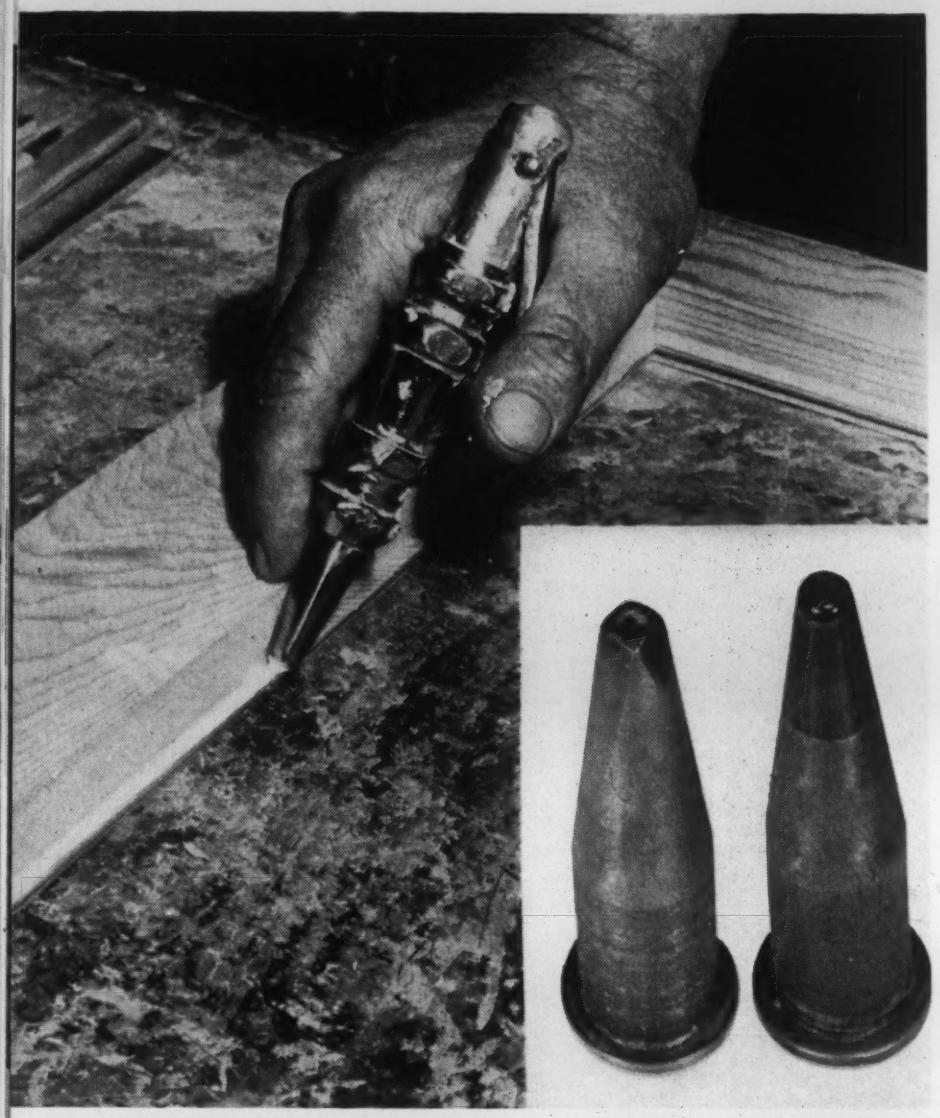
Titanium Rotor Skins The use of titanium for the skins on these helicopter rotors is said to result in an over-all reduction in weight of the helicopter of 68 lb, thus substantially increasing the pay load.

Manufactured and designed by Prewitt Aircraft Co., these blades are being shipped to the Philadelphia Navy Yard where the Bureau of Aeronautics will conduct whirl and flight tests.

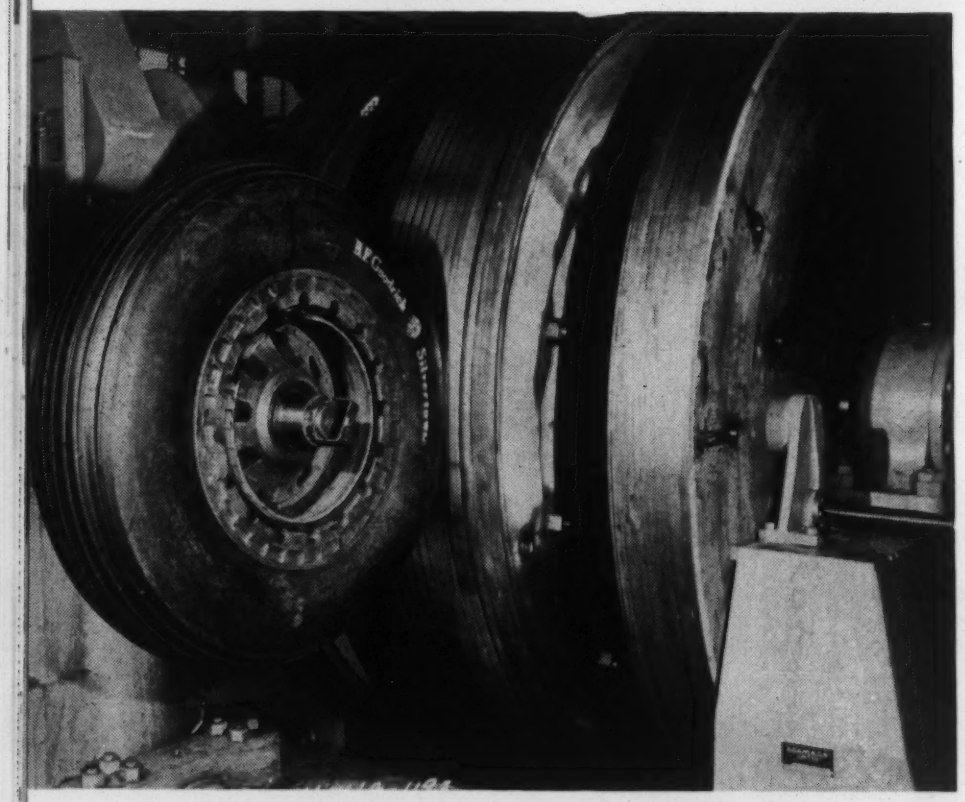


Glass Fiber: From Jet Engines to Awnings Glass fiber today is finding uses in almost every field of manufacture. At upper right is a shielding material for jet aircraft, composed of a glass fiber mat enclosed in stainless steel foil. The foil is sealed around the mat by crimping the edges, and by clamping fasteners. Manufactured by Glass Fibers, Inc., the shields are used for wrapping around the afterburners and ducts of aircraft, to conserve heat in the units and to protect other aircraft structures and operating personnel from the heat.

At the other extreme, polyester-glass fiber laminates are being used for house awnings which are rigid, strong and translucent. Produced by the Dickey Mfg. Co., the awnings shown here have side louvres, permitting two-way circulation of air, and an interlocking attachment allowing simple removal when the house is to be painted.



Carbide Nozzles Out-Squirt Steel The carbide-tipped putty gun nozzle shown at right after 2080 hr of use shows no sign of wear, while the steel nozzle at left is worn out after 54 hr of use. The nozzle is used for applying putty under heavy air pressure on window sashes and doors. Tungsten carbide, supplied by Kennametal, Inc. as grade K-6 Kennametal, has a high hardness, strength, rigidity and wear-resistance.



Torturing Rubber Although it doesn't look like it, this tire and wheel is traveling at 100 mph on the new B. F. Goodrich Co. dynamometer which is capable of loading a wheel up to 70,000 lb at speeds of 264 mph. Such tests simulate stresses sustained by wheels and brakes in landing and stopping today's giant planes. The tire, wheel and brake shown here is used on the Boeing B-52 bomber. The picture was taken with stroboscopic lights at 1/300,000th of a second.

Silicon Carbide Beats Acid Attack At a temperature of 400 F, this semi-scaled steel wire is traveling at a speed of 100 fpm through a 15-20% sulfuric acid pickling bath. Under such service conditions most wear stones have a relatively short life. However, silicon carbide stones (arrow) supplied by the Carborundum Co. have thus far withstood 6 mo of operation with no sign of grooving.

MATERIALS & METHODS
MANUAL No. 109

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

OCTOBER 1954

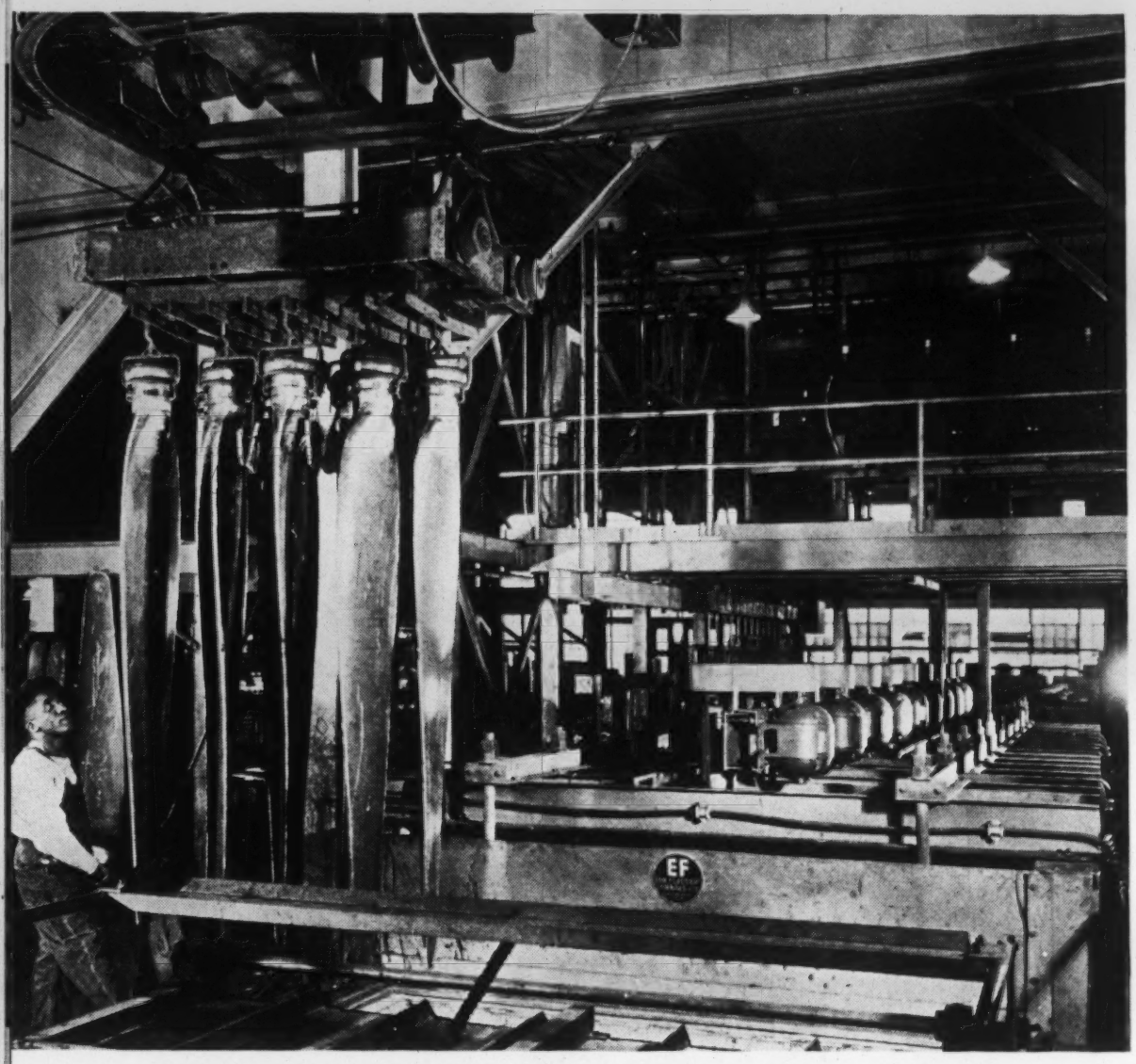
Age-Hardenable Metals

by **JOHN L. EVERHART,** Associate Editor, Materials & Methods

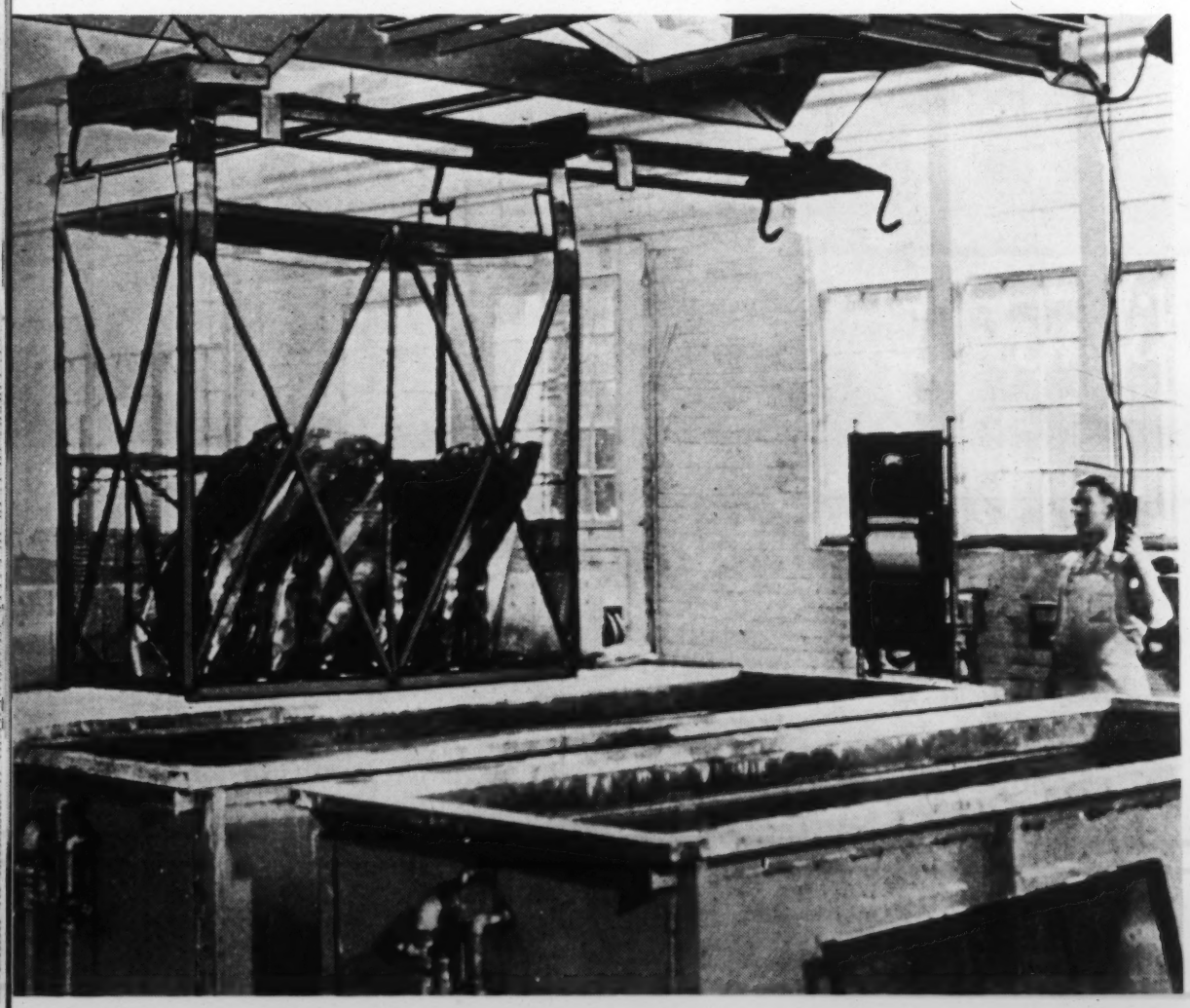
Precipitation or age hardening is a heat treating method which is applicable to many nonferrous and ferrous alloys. This manual discusses the possibilities of the method, the temperature ranges required and the mechanical properties which can be developed in selected commercial alloys in the following groups:

- *Light Metals*
- *Heavy Nonferrous Alloys*
- *Irons and Steels*
- *Superalloys*

TITLE PAGE: Westinghouse vertical furnace for the solution treatment of aluminum shapes up to 50 ft long. Work is dropped through bottom into water pit for fast quench. (Reynolds Metals Co.)



Forged aluminum alloy propeller blades are heat treated in this continuous electric furnace. (The Electric Furnace Co.)



Solution heat treatment of large stampings in an Ajax salt bath. Hoist transfers work from furnace in background to water quench tank.

Introduction

● FOR MANY YEARS, it was considered that the only hardening method which could be applied universally to ductile metals was cold working. Only iron alloys could be hardened by heat treatment. This distinction is no longer true. With the discovery of precipitation, or age hardening, a generalized method of heat treatment became available which is applicable to nonferrous and ferrous alloys. This heat treating procedure opened a broad new field of alloy development which, in some alloy systems, is just being exploited.

The American Society for Testing Materials defines *precipitation hardening* as "hardening caused by the precipitation of a constituent from a supersaturated solid solution". The Society defines *age hardening* as "hardening by aging, usually after rapid cooling or cold working". It is noteworthy that temperature is not included in these definitions.

However, early investigators attempted to differentiate between aging at room temperature and aging at elevated temperatures. Hardening which occurs at room temperature was called "age hardening" while that which requires heating to some elevated temperature was called "precipitation hardening". This distinction which has persisted is merely confusing. With any precipitation hardening alloy, the change can be prevented completely by cooling rapidly to a sufficiently low temperature and holding the material at that temperature. The fact that certain alloys harden at room temperature instead of requiring heating to 300 F, for example, is merely fortuitous. The hardening mechanism is the same at any temperature and in this Manual no distinction is made between age hardening and precipitation hardening. They are used interchangeably.

The basic requirement for age hardening is the presence of a constituent which is more soluble at an elevated temperature than it is at some lower temperature. Any alloy which fulfills this requirement is capable of age hardening. Whether the properties obtained will be commercially significant, however, is another question. Thus far, no arm-chair methods have been found to answer it. The procedures are strictly experimental although certain guide posts can be

set up because of previous experience in the field.

The surface has barely been scratched in the field of alloys suitable for age hardening but it is apparent that the possibilities are enormous. For example, it has been estimated that there are 150 copper-alloy systems in which age-hardenable alloys can be found and it is highly probable that such alloys will be found in virtually all alloy systems.

The mere listing of alloys capable of being age hardened would serve no useful purpose. Most of the work has been done on a laboratory scale and most of the alloys have not been commercialized. This Manual is devoted to a discussion of selected commercial alloys in various systems to indicate the possibilities of the method, the temperature ranges required and the mechanical properties which can be expected in fully aged material.

Age Hardening

In the general case, the heat treatment required to age harden a material is a two stage operation. In the first stage, the alloy is heated to a high temperature for sufficient time to dissolve the solute phase. Quenching from this temperature leaves the solid solution thus formed in an unstable condition. The solute phase then tends to approach a stable condition by precipitating from the solution. The higher the temperature, the more rapidly the change toward equilibrium proceeds.

The aging process must be carefully controlled if optimum properties are to be obtained. In all artificial aging, temperatures must be held within narrow ranges, often within ±10 F of the nominal value. Time must be controlled also. If the aging period is too short, best properties will not be attained, if too long the maximum value will have been passed. Unless maximum properties are required it is preferable to over-age than to under-age because brittleness is reduced and a less critical time period is necessary to obtain substantially the same hardness.

Early investigators believed that the increase in strength obtained by aging a quenched supersaturated solution was the result of precipitation of the second phase in a finely divided form. Later investigation showed however that the increase in strength and hardness could not be derived from precipitation of even minute particles. Current thinking leans toward the conception that lattice distortion during the early stages of precipitation of nuclei is responsible for hardening.

At present, it is generally considered that in the precipitating reaction, the first stage is formation of nuclei of the precipitating phase. This stage is followed by growth of the nuclei into larger particles. The first nuclei tend to appear at grain boundaries and in regions which have been strained either through mechanical working or because of thermal stresses caused by rapid quenching. Later, general precipitation occurs throughout the grain. Finally, the particles agglomerate and over-aging occurs.

If the precipitation reaction is carried out at a suitably high temperature and continued for sufficient time, the resulting structure will be the same as that produced by slow cooling from the solution temperature and similar properties will result. It should be noted that slow cooling is a relative term. Some of these alloys are so sluggish that air cooling is sufficiently rapid to quench the material and retain the solute in solid solution.

Property Changes

During aging, certain property changes occur. Electrical conductivity generally increases. Deviations from this rule are found in aluminum-cop-

Pertinent Definitions

Age Hardening—Hardening by aging, usually after rapid cooling or cold working.

Aging—In a metal or alloy, a change in properties that generally occurs slowly at room temperatures and more rapidly at high temperatures.

Artificial Aging—Aging above room temperature.

Interrupted Aging—Aging at two or more temperatures, by steps, and cooling to room temperature after each step.

Natural Aging—Spontaneous aging of a supersaturated solid solution at room temperature.

Over-aging—Aging under conditions of time and temperature greater than those required to obtain maximum change in a certain property, so that the property is altered in the direction of the initial value.

Precipitation Hardening—Hardening caused by the precipitation of a constituent from a supersaturated solid solution.

Precipitation Heat Treatment—Artificial aging in which a constituent precipitates from a supersaturated solid solution.

Progressive Aging—Aging by increasing the temperature in steps or continuously during the aging cycle.

Quench Aging—Aging induced by rapid cooling after solution heat treatment.

Solution Heat Treatment—Heating an alloy to a suitable temperature, holding at that temperature long enough to allow one or more constituents to enter into solid solution and then cooling rapidly enough to hold the constituents in solution. The alloy is left in a supersaturated, unstable state and may subsequently exhibit quench aging.

Stabilizing Treatment—Any treatment intended to stabilize the structure of an alloy or the dimensions of a part.

Precipitating a constituent from a nonferrous solid solution to decrease the tendency of certain alloys to age harden at room temperature. (Editor's note—for complete definition see reference)

Strain Aging—Aging induced by cold working.

Source: ASTM Designation E44-50T

per alloys while copper-chromium alloys, for example, generally follow the rule.

Increase in hardness passes through a maximum and then decreases, the maximum being reached earlier, the higher the aging temperature. In general strength increases with hardness, although not necessarily in proportion, and ductility decreases. The hardening effect can be varied by interposing mechanical working between the solution and aging steps or by following aging with mechanical work. In some alloys a great increase in strength results. The possibilities of combining mechanical and thermal treatments for obtaining maximum properties have received considerable attention, during the past few years particularly.

During precipitation of the second phase there is a change in volume of the material; whether it is expansion or contraction will depend on the relative specific volumes of matrix and solute.

In magnetic properties, intensity of magnetization should be proportional to the amount of precipitate. Recently it has been demonstrated that in Alnico, Cunife and similar materials the change can be related to degree of age hardening, and for the first time a relationship between this phenomenon and more fundamental properties has been established.

Structural changes may or may not be apparent. In some systems, aging is accompanied by visible precipitation, in others there is no visible sign of aging until the optimum properties have been passed and over-aging has occurred.

Advantages of Age Hardening

Age hardening has certain definite advantages which promise to lead to an increase in the number of alloys developed for hardening by this process.

One major advantage is the possibility inherent in the process of performing mechanical work, fabricating, machining and similar operations on the material in its softest form. Heat treating to the optimum properties, usually at a moderate temperature, follows. This relatively low temperature heat treatment minimizes distortion, excessive scaling and the possibility of cracking the part.

Another advantage, which is apparent particularly in large sections, is the greater uniformity of properties obtainable from surface to center in alloys which are strengthened by cold working alone.

A third advantage is the ability of age hardened alloys to retain their strength at elevated temperatures. The condition produced by aging is not modified by subsequent treatment at a lower temperature although further changes will occur at the same or higher temperatures. Therefore, these alloys usually can be employed at temperatures approaching those used for aging and this is an important factor in considering applications for age hardening materials. Generally these alloys can be used at temperatures above those at which the work-hardened alloys soften. For example, the maximum service temperature for chromium copper and the conductivity grade of beryllium copper is 900 F, and for the normal 2% beryllium copper it is 700 F. This contrasts with 300 F for copper, 400 F for yellow brass and 500 F for phosphor bronze, all of which are work-hardenable materials.

A disadvantage of the age-hardenable alloys lies in their cost. Generally they are more expensive than the work-hardening alloys in the same alloy system.

Light Metals

Possibly because the aluminum copper system was the first in which age hardening was found, application of the principles of precipitation hardening to the development of commercial materials has received greater attention in the light metals than in other alloy fields.

At present, there are at least 25 commercial aluminum alloys in which properties can be improved by heat treatments of this type. There are also about 7 magnesium alloys in this category. In the titanium field, heat treatment is still under investigation but there are indications that some of the present commercial alloys can be hardened by precipitation heat treatments.

Aluminum Alloys

Most commercial age-hardenable aluminum alloys are based on three alloy systems: copper, magnesium-silicide and zinc. Of these the copper alloys are most widely used in both wrought and cast form.

Wrought aluminum copper alloys usually contain from 2.5 to 5.5% copper and may also carry small quantities of magnesium and manganese. Those alloys containing magnesium generally age naturally at room temperature to their optimum properties while those without magnesium usually require artificial aging at elevated temperatures. Among wrought copper-bearing alloys are 2017 and 2024. Although the copper content ranges up to 10% in the casting alloys, most of them range from 4 to 5% copper and may contain additional silicon to improve fluidity. Typical cast aluminum copper alloys are 195 and A195.

Alloys based on magnesium and silicon comprise most of the remaining hardenable aluminum materials. Wrought alloys of this type usually contain sufficient magnesium and silicon to produce magnesium silicide in the range 0.7 to 1.3%. A typical alloy is 6061. Casting alloys of this type usually include excess silicon to promote castability. Alloys in this group are 355 and 356. In both wrought and cast alloys of the magnesium silicide type, small concentrations of heavy metals, such as chromium or nickel, are sometimes included to control grain size.

A third major group and one in which the strongest aluminum alloys have been found is based on zinc. This system is relatively new in the commercial field; the most widely known alloy is 7075.

In order to indicate the condition of an aluminum alloy, a code has been developed by the aluminum industry. The basic designations for heat treated materials are:

-T4—solution heat treated
-T5—artificially aged
-T6—solution heat treated and artificially aged
-T7—solution heat treated and

stabilized (over-aged)
-T8—solution heat treated, cold worked, artificially aged
-T9—solution heat treated, artificially aged, cold worked

Modification of the basic treatment is indicated by additional digits. Thus -T61 indicates a change in the basic -T6 treatment.

Heat Treatment — The temperatures employed for solution heat treating vary with alloy composition, but for both cast and wrought material lie generally in the range 825 to 980 F. For the individual alloy, careful control within a narrow range (± 10 F) is required. If the temperature is too low, maximum strength is not achieved, if too high, there is danger of incipient melting of low-melting constituents.

Time of holding at solution temperature varies from about 10 min for thin sheet to 12 hr for heavy parts. A general rule is one hour per inch of thickness. Although clad material is heat treated by the procedures used for the unclad alloy, excessive heating time will cause diffusion of constituents such as copper from the base metal into the coating and can seriously reduce corrosion resistance, thus defeating the purpose of cladding.

Solution treated material is quenched into water to obtain optimum conditions for subsequent aging. Cold water can be used for thin sections but, to minimize distortion, hot water is used for heavy sections.

Aging in some of the alloys occurs at room temperature and alloys of this type attain their full strength in from 4 to 5 days although it requires only about one day to reach 90% of optimum strength. For alloys requiring artificial aging, temperatures in the range 250 to 375 F are used with wrought alloys and 310 to 600 F for castings. Temperature depends on the alloy and properties desired. Time varies from about 6 to 24 hr.

Properties—Properties of a representative group of aluminum alloys are included in a table. Selecting 2014 as an example of the improvement possible in a wrought alloy through age hardening, yield strength increases from 14,000 psi in the annealed condition to 60,000 psi in the fully aged condition while hardness is tripled. At the same time, ductility as measured by elongation falls from 18 to 13%. With 7075 the improvement is greater; yield strength increases from 15,000 to 72,000 psi and Brinell hardness from 60 to 150 and elongation drops from 16 to 11%.

Improvements in cast alloys, though substantial, are not so great as in the wrought materials. In type 122, yield strength increases from 20,000 psi for annealed material to 40,000 psi for fully aged material and hardness increases only from 80 to 115.

It is noteworthy that the electrical conductivities of these aluminum alloys are not improved by age-hardening treatments. This is in sharp contrast with results of precipitation hardening on copper alloys. Conductivity is not particularly important in the major applications of these aluminum alloys, however.

Magnesium Alloys

Commercial age-hardenable magnesium alloys most widely used at present are those based on aluminum. Although alloys within the range 2 to 12% aluminum should be age hardenable, for practical purposes only those containing more than 6% aluminum are improved appreciably by such treatment. In the wrought alloy field, only the alloy designated commercially as 0-1 or AMC58S is used to any great extent in the heat treated condition. Several casting alloys are used, particularly those shown in the accompanying table.

The types of heat treatments employed commercially are:

-T4—solution heat treatment
-T5—artificially aged
-T6—solution heat treated and artificially aged
-T7—solution heat treated and stabilized (over-aged)

As is the case with the aluminum alloys, modifications of the basic treatments are indicated by additional digits.

Heat Treatment—The solution heat treatment varies with the alloy. In general, however, wrought material is heated to 725-775 F for a period of time which depends on the size of the piece. Castings are heated to the range 650 to 1050 F for a period which is long enough to dissolve most of the soluble constituent. For the individual alloy, control within a narrow temperature range is required. Since rate of precipitation is slower in magnesium alloys than in aluminum alloys, a less drastic quench can be used. In commercial practice, cooling in still air or in a stream of moving air produced by a fan is sufficient for most purposes. However, cooling in moving air is essential if the T-4 condition is to be retained. Magnesium alloys, unlike certain aluminum alloys, do not age harden appreciably at room temperature. Elevated temperature treatment is required to achieve a useful increase in hardness.

Artificial aging following a solution heat treatment requires heating in the range 300 to 500 F for periods of time depending on the section size. Various combinations of time and temperature can be used. To complete the aging process, less time is required at the higher temperatures, somewhat higher elongations are obtained but the yield strength is reduced.

A modified heat treatment procedure is required for some magnesium alloys since they have a tendency toward grain growth. To overcome this tendency, an interrupted solution heat treatment is used. Permanent mold castings of the alloy G or AM240, for example, are often solution heat treated by heating for 2 to 3 hr at 785 F cooling to 300-400 F, reheating to 785 F for 18 to 24 hr.

Forging an aluminum alloy aircraft component. (Aluminum Company of America)

Commercial Designation	Composition, %	Condition
ALUMINUM ALLOYS—WROUGHT		
2014 (14S)	4.4 Cu, 0.8 Si, 0.8 Mn, 0.4 Mg	Ann at 775 F, 2–3 hr Sol H.T. at 940 F Sol H.T. at 940 F, aged 340 F, 8–12 hr
2017 (17S)	4.0 Cu, 0.15 Mn, 0.5 Mg	Ann at 775 F, 2–3 hr Sol H.T. at 940 F
2024 (24S)	4.5 Cu, 0.6 Mn, 1.5 Mg	Ann at 775 F, 2–3 hr Sol H.T. at 920 F Sol H.T. at 920 F, cold worked
6061 (61S)	0.25 Cu, 0.6 Si, 1.0 Mg, 0.25 Cr	Ann at 775 F, 2–3 hr Sol H.T. at 970 F Sol H.T. at 970 F, aged 320 F, 16–20 hr or 350 F, 6–10 hr
7075 (75S)	1.6 Cu, 7.5 Mg, 0.3 Cr, 5.6 Zn	Ann at 775 F, 2–3 hr Sol H.T. at 870 F, aged 250 F, 24–28 hr
ALUMINUM ALLOYS—SAND CAST		
122	10 Cu, 0.2 Mg	Annealed Sol H.T. at 950 F, 12 hr, aged 310 F, 10–14 hr
142	4 Cu, 1.5 Mg, 2 Ni	Cast aged 650 F, 2–4 hr Sol H.T. at 960 F, 4 hr, aged 650 F, 1–3 hr
195	4.5 Cu	Sol H.T. at 960 F, 12 hr Sol H.T. at 960 F, 12 hr, aged 310 F, 12–20 hr
355	5 Si, 1.3 Cu, 0.5 Mg	Cast, aged 440 F, 7–9 hr Sol H.T. at 980 F, 12 hr, aged 310 F, 8–10 hr
356	7 Si, 0.3 Mg	Cast, aged 440 F, 7–9 hr Sol H.T. at 1000 F, 12 hr, aged 310 F, 3–5 hr
ALLUMINUM ALLOYS—PERMANENT MOLD CAST		
142	4 Cu, 1.5 Mg, 2 Ni	Cast, aged 340 F, 22–26 hr Sol H.T. at 960 F, 6 hr, aged 400 F, 3–5 hr
B195	4.5 Cu, 2.5 Si	Sol H.T. at 950 F, 8 hr Sol H.T. at 950 F, 8 hr, aged 310 F, 5–7 hr
333	3.8 Cu, 9 Si	Cast, aged 400 F, 7–9 hr Sol H.T. at 940 F, 8 hr, aged 310 F, 2–5 hr
355	1.3 Cu, 5 Si, 0.5 Mg	Cast, aged 440 F, 7–9 hr Sol H.T. at 980 F, 8 hr, aged 340 F, 14–18 hr
MAGNESIUM ALLOYS—WROUGHT		
Dow / Alcoa		
01 / AMC58S	8.5 Al, 0.5 Zn, 0.2 Mn	Press Forged Press Forged, aged 350 F, 16–24 hr As Extruded Extruded, Sol H.T. at 750 F, aged 350 F, 16–24 hr
MAGNESIUM ALLOYS—SAND OR PERMANENT MOLD CAST		
G / AM240	10 Al, 0.2 Mn	As cast Sol H.T. at 780–800 F, 18–24 hr Sol H.T. at 780–800 F, 18–24 hr, aged 325–400 F, 10–12 hr
C / AM260	9 Al, 2 Zn, 0.2 Mn	As cast Sol H.T. at 760–775 F, 18–22 hr Sol H.T. at 760–775 F, 18–22 hr, aged 400–425 F, 5-15 hr
H / AM265	6 Al, 3 Zn, 0.2 Mn	As cast Sol H.T. at 720–740 F, 10–15 hr Sol H.T. at 720–740 F, 10–15 hr, aged 400–425 F, 5–15 hr
AZ91C / AMA263	8.7 Al, 0.7 Zn, 0.2 Mn	As cast Sol H.T. at 775–790 F, 18–20 hr Sol H.T. at 775–790 F, 18–20 hr, aged 400–425 F, 3–5 hr

* *Sheet.*

Temper	Density, lb/cu in.	Elect Cond, % I.A.C.S.	Yield Strength, psi (0.2% offset)	Tensile Strength, psi	Elong, % (2 in.)	Hardness Brinell	Fatigue Strength, psi (5×10^8 cycles)	Shear Strength, psi
-O	0.101	50	14,000	27,000	18	45	13,000	18,000
-T4	0.101	—	40,000	62,000	20	105	20,000	38,000
-T6	0.101	40	60,000	70,000	13	135	18,000	42,000
-O	0.101	45	10,000	26,000	22	45	13,000	18,000
-T4	0.101	30	40,000	62,000	22	105	18,000	38,000
-O	0.100	50	11,000	27,000	19*	47	13,000	18,000
-T3	0.100	30	50,000	70,000	16*	120	20,000	41,000
-T36	0.100	—	57,000	73,000	13*	130	18,000	42,000
-O	0.098	45	8,000	18,000	30	30	9000	12,500
-T4	0.098	40	21,000	35,000	25	65	13,500	24,000
-T6	0.098	40	40,000	45,000	17	95	13,500	30,000
-O	0.101	—	15,000	33,000	16	60	—	22,000
-T6	0.101	30	72,000	82,000	11	150	24,000	49,000
-T2	0.107	41	20,000	27,000	1.0	80	9500	21,000
-T61	0.107	33	40,000	41,000	—	115	8500	32,000
-T21	0.102	44	18,000	27,000	1.0	70	6500	21,000
-T77	0.102	38	23,000	30,000	2.0	75	10,500	24,000
-T4	0.102	35	16,000	32,000	8.5	60	7000	26,000
-T62	0.102	35	34,000	40,000	1.5	95	8000	32,000
-T51	0.098	43	23,000	28,000	1.5	65	7000	22,000
-T61	0.098	37	35,000	39,000	1.0	90	8500	31,000
-T51	0.097	43	20,000	25,000	2.0	60	7500	20,000
-T6	0.097	39	24,000	33,000	3.5	70	8500	26,000
-T571	0.102	34	34,000	40,000	1.0	105	10,500	30,000
-T61	0.102	33	42,000	47,000	0.5	110	9500	35,000
-T4	0.101	33	19,000	37,000	9.0	75	9500	30,000
-T6	0.101	33	26,000	40,000	5.0	90	10,000	32,000
-T5	0.100	29	25,000	34,000	1.0	100	12,000	27,000
-T6	0.100	29	30,000	42,000	1.5	105	15,000	23,000
-T51	0.098	43	24,000	30,000	2.0	75	10,000	24,000
-T62	0.098	36	40,000	45,000	1.5	105	10,000	36,000
—	0.065	10.8	30,000	45,000	7	64	17,000	22,000
-T5	0.065	14.6	34,000	50,000	6	72	16,000	22,000
—	0.065	10.8	36,000	48,000	14	62	18,000	21,500
-T51	0.065	14.6	39,000	54,000	6	80	—	—
-F	0.066	11.5	12,000	22,000	2	53	10,000	18,000
-T4	0.066	9.9	13,000	40,000	10	52	11,000	20,000
-T6	0.066	11.0	20,000	40,000	4	60	10,000	21,000
-F	0.066	12.3	14,000	25,000	2	65	12,000	18,000
-T4	0.066	10.5	14,000	40,000	10	63	13,000	20,000
-T6	0.066	12.3	22,000	40,000	3	81	12,000	22,000
-F	0.066	15.0	11,000	27,000	6	51	11,000	18,000
-T4	0.066	12.3	13,000	40,000	15	53	12,000	18,000
-T6	0.066	13.8	19,000	40,000	5	71	11,000	20,000
-F	0.066	10.2	14,000	24,000	25	60	—	—
-T4	0.066	9.9	13,000	40,000	15	55	—	—
-T6	0.066	11.2	19,000	40,000	5	70	—	—

Properties — The improvement achieved by age hardening the magnesium alloys is not so great as that obtained in aluminum alloys. This is apparent from a study of the table. In the wrought material, strength and hardness are slightly improved but ductility is lowered. In the cast alloys, although yield strength of fully aged alloys is increased roughly 50% over solution treated materials, tensile strength remains unchanged and ductility, as measured by elongation, is reduced considerably. The hardness is increased. Aged alloys, however, show considerable improvement in properties over the "as-cast" materials.

Titanium Alloys

Most work done in this field has been on experimental alloys on a laboratory scale, and procedures for the commercial alloys are not developed. It has been reported that 7% manganese-titanium alloy can be age hardened by heating to 1300 F for 2 hr, air cooling, and aging at 800 F for 8 hr. A yield strength of 150,000 psi and an elongation of 12% is obtained by this treatment. This contrasts with a yield strength of 120,000 psi and 10% elongation for the annealed material.

On certain experimental alloys, containing from about 5 to 8% of manganese, chromium, iron or combinations of these elements, hardness increases up to 100 Vickers numbers have been achieved by aging in the range 200 to 300 F.

In most work on aging of titanium alloys, however, significant increases in hardness have been accompanied by extreme brittleness, and the problems of developing suitable age-hardening schedules for titanium alloys are far from solved.

Heavy Nonferrous Alloys

This field covers a wide range of alloys and has been investigated quite extensively on a laboratory basis. Age-hardenable alloys have been found in systems based on copper, gold, lead manganese, nickel, palladium, platinum, silver, and zinc. It

Beryllium copper components are aged at 600 to 650 F to obtain maximum strength and hardness. (Beryllium Corp.)

is highly probable that such alloys will be found in virtually all alloy systems.

It is not possible to cover all age-hardenable alloys in this category and it would serve no particularly useful purpose to attempt to list them. A brief discussion of some of the alloys in commercial usage will give an idea of the possibilities. Of these materials, the copper and nickel base alloys are most important. A number are discussed below. To indicate the range of properties obtainable in other alloy systems, several lead, gold, palladium, platinum and silver alloys are discussed also.

Copper Alloys

Although it has been estimated that age-hardenable alloys are found in at least 150 copper-alloy systems, only a few of these materials are widely used commercially. Most common of these are beryllium copper, chromium copper and nickel-phosphorus copper. There are other age-hardenable copper alloys which are used for specialized applications, but these are representative of the copper-base alloys.

Beryllium Copper — There are a number of modifications of beryllium copper. The most widely used wrought alloy contains about 2% beryllium and 0.35% of either cobalt or nickel. This alloy combines the maximum strength obtainable in a commercial copper alloy with relatively high electrical conductivity. By sacrificing some strength, electrical conductivity can be more than doubled. This is accomplished with an alloy containing about 2% cobalt with 0.6% beryllium. Various other combinations of both cast and wrought materials are produced. One casting alloy, for example, contains 1.5% nickel and 0.25% beryllium

Like aluminum and magnesium alloys, temper designations are used to indicate the condition of beryllium copper alloys. These designations are:

A—solution heat treated and quenched.

AT — solution heat treated, quenched and aged.

H — solution heat treated, quenched and cold rolled to the hard condition.

HT — solution heat treated, quenched, cold rolled to the hard condition, and aged.

Modifications of the designations are used for other conditions. Thus ½ HT indicates cold rolled half hard and aged.

Heat treatments for beryllium coppers vary with the alloy. For those alloys containing 2% or more beryllium, solution heat treatment requires heating to the range 1450 to 1500 F and quenching. These alloys are aged in the range 600 to 650 F for periods ranging from 1 to 3 hr. For the high-conductivity alloys, containing less than 1% beryllium, the solution temperature is raised to 1675 to 1700 F, and the alloys are aged at 850 to 900 F. These heat treatments can be used for both cast and wrought material.

Properties of a number of beryllium coppers are given in a table. An examination of this table indicates the improvement possible by age hardening. The common wrought 2% beryllium copper alloy shows an improvement in yield strength from 25,000 psi to 80,000 psi upon aging from the soft condition. If a cold-working step is interposed between the solution and aging treatments, yield strengths can be still further increased to values as high as 110,000 psi. There is some reduction in ductility during age hardening of this alloy but electrical conductivity increases from about 17 to 21% I.A.C.S. However, this grade of beryllium copper is designed for maximum strength rather than conductivity. In a 2.6% cobalt-0.5% beryllium alloy, electrical conductivity can be increased from 26% to about 54% by aging, although the alloy cannot be heat treated to as high strengths as are possible in alloys with higher beryllium content.

Chromium Copper — Commercial copper chromium alloys contain from about 0.85 to 1% chromium with or without small additions of other elements such as silicon or silver. These alloys are solution treated at temperatures of about 1825 F and aged at 900 to 950 F. Aging does not produce as high a strength as is obtained in beryllium copper but yield strengths of 55,000 psi are obtainable. On the other hand, improvement in electrical conductivity is marked. In the aged condition, chromium copper can show about 80% I.A.C.S. This is probably the highest conductivity obtainable in a commercial age-hardenable alloy.

Nickel-phosphorus-copper — The third commercial age-hardening alloy is based on nickel and phosphorus. The alloy contains about 1% nickel and 0.25% phosphorus. A free-machining grade containing tellurium is also produced which has properties similar in general to the tellurium-free alloy. This alloy can be solution treated at 1400 F and aged at about 850 F. Maximum strength obtainable is somewhat lower than that achieved in the beryllium or chro-

mium copper alloys. However, electrical conductivity of the aged alloy is 60% and lies between chromium copper and the conductivity grade of beryllium copper.

Nickel Alloys

Most commercial age-hardenable nickel alloys are based on the addition of aluminum, silicon, titanium, chromium or beryllium to nickel. The wrought alloys K Monel and KR Monel are nickel-copper-aluminum alloys, the KR grade containing increased carbon to improve machinability. Duranickel is a nickel-aluminum-titanium alloy. Permanickel is a high nickel alloy containing titanium and magnesium. There are also a number of special purpose age-hardenable alloys having controlled expansion coefficients or constant modulus properties over a temperature range. Ni-Span C is an alloy in this group. Alloys used in cast form include beryllium nickel and S-Monel, a nickel-copper-silicon alloy.

Some of these nickel alloys do not require a preliminary solution treatment before aging. Thus, K-Monel, KR-Monel and Duranickel can be hardened by a single heat treatment, the temperature range depending on the condition of the material. For soft or moderately worked material, temperatures of 1080 to 1100 F can be used while fully cold-worked material must be aged at a lower temperature in the range 980 to 1000 F to prevent over-aging. Like beryllium copper alloys, maximum strength is attained by cold working followed by aging. Ni-Span C requires a solution heat treatment at 1750 to 1950 F followed by aging at 1100 to 1350 F.

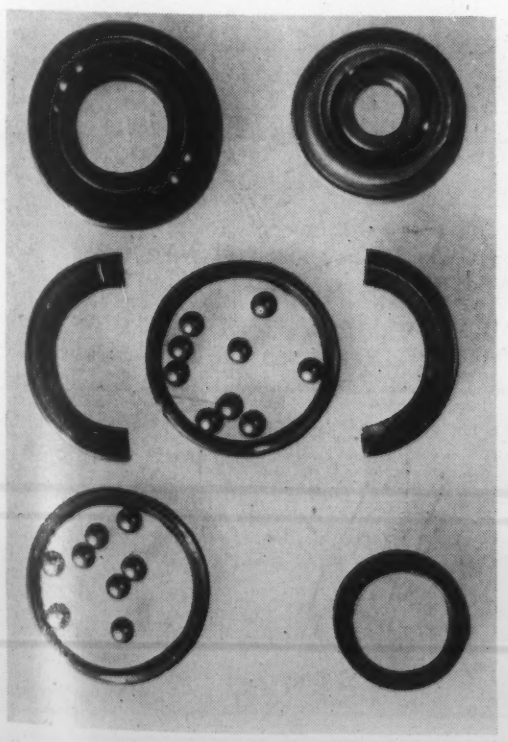
S-Monel is used in cast form and age hardening is accomplished by a solution heat treatment at about 1600 F followed by aging at 1100 F. Cast beryllium nickel requires solution heat treatment at about 1950 F followed by aging at 950 F.

Properties — The properties of some of these materials are given in a table. As an example of improvement in strength possible through aging, Duranickel as quenched has a yield strength of about 47,000 psi, aging increases this figure to 114,000, while cold worked followed by aging increases the yield strength to 191,000 psi. Thus, a four-fold increase in yield strength can be obtained. The ductility is reduced about two thirds by this treatment.

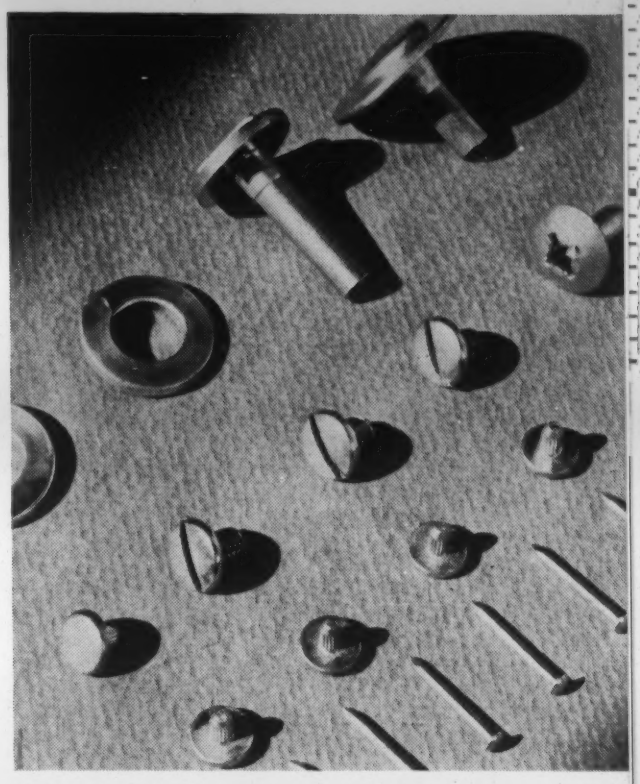
The mechanical properties of S-Monel castings are not changed markedly by aging treatments. Strengths are practically the same in both cast and aged condition but there is some increase in hardness as the result of aging. On the other hand, beryllium nicked castings can be improved considerably by heat treatment. Yield strength is increased only about 10,000 psi by aging from the cast condition, but by interposing a solution treatment before aging, yield strength can be almost quadrupled, increasing from 50,000 to 180,000 psi.

Ni-Span C is an example of special properties which can be obtained in an age-hardened material. During the precipitation treatment, an intermetallic compound of nickel and titanium is precipitated. This changes the composition of the matrix alloy and shifts the elasitc coefficient.

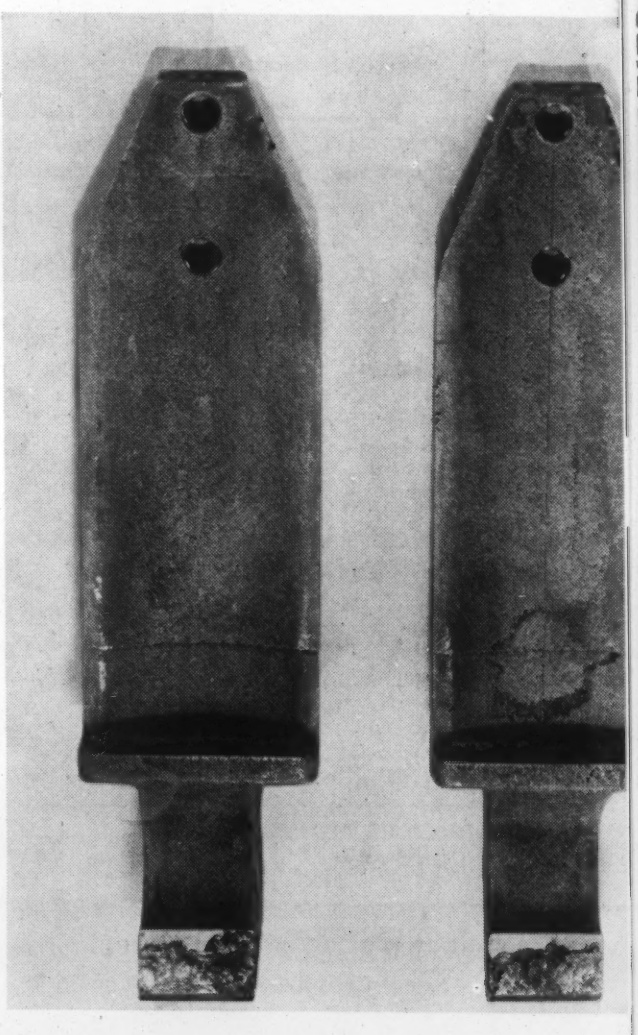
The ability to shift the coefficient is a significant difference between this material and other constant modulus alloys, which depend entirely on chemical composition for control of the coefficient. As solution annealed, Ni-Span C has a slightly negative coefficient. During precipitation, the coefficient is shifted in the positive direction, the extent of the shift depending on aging time and temperature. Through proper selection of heat treatment, this alloy can be adjusted to give a negative, zero or positive thermoelastic coefficient with-



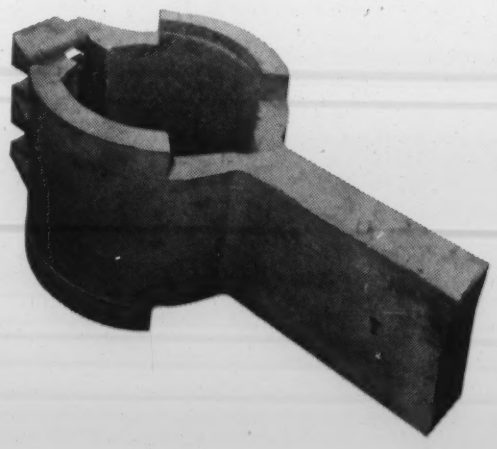
Ball bearing assemblies of K-Monel. The balls are heat treated to a hardness of 400 to 430 Brinell. (International Nickel Co.)



Nickel-phosphorus copper components can be solution treated at 1400 F and aged at about 850 F. (Chase Brass & Copper Co.)



Chromium copper contact extension for a 330 KV oil circuit breaker cast by Westinghouse.



A 1400-lb chromium copper electrode holder for an arc melting furnace cast by P. R. Mallory.

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Some Age-Hardenable

Material	Composition,* %	Form	Treatment
COPPER ALLOYS			
Beryllium Copper	2 Be, 0.25 Co	Strip	Sol H.T. at 1425 F, quenched Sol H.T. at 1425 F, quenched, aged 600 F, 3 hr Sol H.T. at 1425 F, quenched, cold-rolled 37% Sol H.T. at 1425 F, quenched, cold-rolled 37%, aged 600 F, 2 hr
Cobalt Beryllium Copper	2.6 Co, 0.5 Be	Strip	Sol H.T. at 1675 F, quenched Sol H.T. at 1675 F, quenched, aged 875 F, 3 hr
Nickel Beryllium Copper	1.5 Ni, 0.25 Be	Sand Cast	As cast Sol H.T. at 1650 F, quenched Sol H.T. at 1650 F, quenched, aged 850 F, 2 hr
Chromium Copper	0.85 Cr, 0.1 Si	Rod	Sol H.T. at 1830 F, quenched Sol H.T. at 1830 F, quenched, aged 930 F, 3 hr
Chromium Copper	1.0 Cr	Wrought Cast	Sol H.T., quenched, aged Sol H.T., quenched, aged
Nickel-Phosphorus-Copper	1.1 Ni, 0.22 P	Wire	Sol H.T. at 1400 F, quenched Sol H.T. at 1400 F, quenched, aged at 850 F
NICKEL ALLOYS (see also Superalloys)			
Duranickel	4.4 Al, 0.4 Ti	Strip	Sol H.T. at 1600 F, quenched Sol H.T. at 1600 F, quenched, aged 1100 F, 8 hr Cold-rolled 50%, aged 1000 F, 8 hr
K-Monel	29 Cu, 2.75 Al, 0.5 Ti, 0.9 Fe, 0.15 C	Strip	Sol H.T. at 1600 F, quenched Sol H.T. at 1600 F, quenched, aged 1100 F, 8 hr Cold-rolled 50%, aged 1000 F, 8 hr
S-Monel	29.5 Cu, 4 Si, 2 Fe, 0.1 C, 0.8 Mn	Sand Cast	As Cast Sol H.T. at 1600 F, quenched, aged 1100 F, 4 hr
Ni-Span C	2.5 Ti, 5.5 Cr, 0.03 C	Strip	Sol H.T. at 1750 F, quenched Sol H.T. at 1750 F, quenched, aged 1250 F Sol H.T. at 1750 F, quenched, cold worked 50%, aged 1250 F
Beryllium Nickel	2.75 Be, 0.5 C max	Cast	As cast Sol H.T. at 1950 F, quenched, aged 950 F, 5 hr
LEAD ALLOYS			
Antimonial Lead	4 Sb	Strip	Cold-rolled, 95% red Sol H.T. at 450 F, quenched, aged 1 day r.t.
Antimonial Lead	8 Sb	Strip	Cold-rolled, 95% red Sol H.T. at 450 F, quenched, aged 1 day r.t.
PRECIOUS ALLOYS			
Gold Alloy	15.5 Ag, 13 Cu, 0.5 Zn	Wrought	Sol H.T. at 1300 F Sol H.T. at 1300 F, cooled from 840 F to 480 F in 30 min Sol H.T. at 1300 F, aged 575 F, 15 min
Dental Gold Alloy	16 Pt, 12.5 Cu, 9 Ag, 4.5 Pd, 1 Zn, 0.5 Ni	Wire	Sol H.T. at 1300 F, quenched Sol H.T. at 1300 F, quenched, oven cooled from 840 F to 480 F in 30 min
Dental Gold Alloy	14 Cu, 9.5 Ag, 5 Pt, 0.5 Ni, 0.5 Zn	Cast	Sol H.T. at 1300 F, quenched Sol H.T. at 1300 F, quenched, oven cooled from 840 F to 480 F in 30 min
Dental Palladium Alloy	40 Ag, 16 Cu, 0.5 Ni, 0.5 Pt	Wire	Sol H.T. at 1300 F, quenched Sol H.T. at 1300 F, quenched, oven cooled from 840 F to 480 F in 30 min
Platinum-copper	4.5 Cu	Wrought	Cold-drawn 50% Cold-drawn 50%, aged 840 F, 10 min
Silver Alloy	0.3 Mg, 0.2 Ni	Strip	Annealed at 700 F Aged at 1475 F in oxidizing atmosphere
Sterling Silver	7.5 Cu	Wrought	Sol H.T. at 1200 F, quenched Sol H.T. at 1200 F, quenched, aged 615 F, 30 min

NOTES:
[1] *Proportional limit.* [2] *Elastic limit.* [3] *Elongation in 8 in.* [4] *Minimum.*
* *Remainder—base metal.*

Heavy Nonferrous Alloys

Temper	Density, lb/cu in.	Elect Cond, % I.A.C.S.	Yield Strength, psi	Tensile Strength, psi	Elong, % (2 in.)	Hardness		Fatigue Strength, psi (10^8 cycles)
						Brinell	Rockwell	
A	0.297	17	25,000	72,000	50	—	B60	32,500
AT	0.298	21	80,000	175,000	5	—	C41	35,600
H	—	—	70,000	107,000	6	—	B97	36,800
HT	—	—	110,000	195,000	3	—	C42	40,700
A	0.316	26	25,000	50,000	30	—	B33	—
AT	0.317	54	75,000	110,000	10	—	B96	30,000
—	0.299	42	17,000[1]	51,000	16	110	—	—
A	0.299	38	6000[1]	36,600	35	55	—	—
AT	0.300	50	46,000[1]	82,000	6	200	—	—
—	0.321	34	14,000	45,000	40	—	—	—
—	—	76	56,000	71,000	21	—	B70	—
—	—	78	—	77,000	2	—	A50	—
—	—	80	—	50,000	15	—	A42	—
—	0.323	32	10,000	38,000	40	—	—	—
—	—	60	40,000	65,000	25	—	—	—
—	0.298	4	47,000	104,000	42	—	C4	—
—	—	—	114,000	167,000	28	—	C32	—
—	—	—	191,000	214,000	13	—	C42	—
—	0.306	2.9	50,000	100,000	39	—	C3	—
—	—	—	98,000	140,000	27	—	C26	—
—	—	—	174,000	189,000	11	—	C39	—
—	0.302	—	95,000	125,000	2.5	310	—	—
—	—	—	95,000	125,000	2.5	340	—	—
—	0.294	1.4	35,000	90,000	40	125	B70	—
—	—	1.7	115,000	180,000	18	305	C33	—
—	—	1.7	180,000	200,000	7	395	C42	—
—	—	3	60,000[4]	115,000[4]	5	—	C24	—
—	—	3	180,000[4]	195,000[4]	0	—	C52	—
—	0.398	—	—	4000	48	8	—	—
—	0.398	7.7	—	11,700	6	24	—	—
—	0.388	—	—	4600	31	9	—	—
—	0.388	7.5	—	12,600	5	26	—	—
—	—	—	41,000[1]	65,000	33[3]	—	—	—
—	—	—	63,000[1]	93,000	4[3]	—	—	—
—	—	—	68,000[1]	106,000	10[3]	—	—	—
—	0.601	—	87,000[1]	120,000	17[3]	170	—	—
—	—	—	140,000[1]	174,000	8[3]	265	—	—
—	—	—	41,000[2]	57,000	5.5	149	—	—
—	—	—	69,000[2]	94,000	1	205	—	—
—	0.396	—	75,000[1]	105,000	20[3]	175	—	—
—	—	—	117,000[1]	150,000	11[3]	257	—	—
—	—	—	59,000[1]	81,000	1.5	—	—	—
—	—	—	85,000[1]	98,000	—	—	—	—
—	—	—	—	31,000	35	—	30T-20	—
—	—	75	57,000	67,000	8	—	30T-67	—
—	0.371	—	20,000	37,000	42	—	—	—
—	—	—	30,000	43,000	25	—	—	—

in the range -20 to $+20 \times 10^{-6}$ per °F.

Lead Alloys

Commercially, the most important age-hardenable lead alloys are based on the lead-antimony system, although a calcium-lead alloy is used for specialized applications.

The properties of typical antimonial leads are given in a table. Although strength and hardness can be tripled by aging treatments, little advantage is taken of this possibility in commercial practice. It has been said that the fatigue strength of these alloys is improved by aging treatments but data are not available. The alloys age at room temperature, a fact which on occasion has led to difficulties, particularly in thin sections, since ductility is reduced considerably.

Alloys of calcium and lead containing about 0.025% calcium can also be considerably improved by aging. Tensile strength can be increased from 3000 to 4500 psi while elongation falls from 40% to 25% during aging. It has been stated that creep strength and fatigue strength can be improved also by aging treatments.

Precious Alloys

One of the earliest indications that differences in solubility alone were not the only criterion of useful age hardening occurred in the silver copper system. Sterling silver, commonly a silver alloy containing 7.5% copper, appears to be an ideal age-hardenable alloy. Actually, very little improvement is possible in this alloy as shown in a table. By substitution of other elements for part of the copper, greater increase in strength has been achieved but these age-hardenable sterling silvers have found little favor. Because of the specialized usage of sterling, for tableware as an example, color is important and modified sterling alloys have not been sufficiently close to the original sterling, in color, to appeal to the purchaser.

An age-hardenable high silver alloy containing magnesium and nickel is in production. This alloy is interesting because it owes its age-hardening properties to selective oxidation rather than to the precipitation of an intermetallic compound. Only a single heat treatment is necessary to reach maximum hardness. The alloy is heated at about 1475 F in an oxidiz-

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ing atmosphere for a period of time proportional to its thickness, with the object of diffusing oxygen uniformly through the cross-section. By aging, the tensile strength of this alloy can be almost doubled, while an even greater increase in hardness is achieved. The electrical conductivity of the aged alloy is 75%, making it one of the best conductors of the age-hardenable materials.

In the precious metals field, greatest use of age hardening has occurred in dentistry and electrical applications. The dental gold alloys used for the purpose generally contain varying quantities of metals of the platinum group, silver, copper, nickel, zinc and sometimes other elements. Alloys are proprietary and little information on their compositions is available. However, several gold alloys are included in a table to give some idea of the improvement possible.

In the dental field, the alloys are generally quenched from 1300 F and aged by cooling at a controlled rate from about 850 to 475 F. This system was devised because it was more readily applicable to a laboratory having limited equipment than a closely controlled temperature range. That optimum values may not result is indicated by the figures given for a silver-copper-zinc-gold alloy. The tensile strength obtainable by the jeweler's standard treatment is 93,000 psi and the elongation is 4%. By aging at a selected temperature, strength can be increased to 106,000 psi and elongation to 10%.

Strengths obtainable in these precious alloys are excellent. As shown in the table, a gold alloy can be aged to a tensile strength of 174,000 psi and a palladium alloy to 150,000 psi. Although these results were obtained on wire, they are in the upper portion of the strength range obtainable in age-hardenable nonferrous alloys. Among the proprietary alloys developed for the electrical field is a palladium-platinum gold-silver-copper alloy. This alloy developed for contacts and resistance wire has a tensile strength of 120,000 psi and an elongation of 24% in the annealed condition. By aging, the strength can be increased to 180,000 psi while elongation drops to 9%. Other precious alloys show strengths of the order of 90,000 to 100,000 psi after aging. Hardness values reported for these alloys have not been so high as those for other nonferrous age-hardenable materials however.

Some Age-Hardenable

Commercial Designation	Composition, %	Form	Condition
STAINLESS STEELS (see also Superalloys)			
Armco 17-4PH	16.5 Cr, 4 Ni, 4 Cu, 0.35 Cb+Ta, <0.07 C	Bar	Sol H.T. at 1900 F, o.q. Sol H.T. at 1900 F, o.q., aged 1000 F, 4 hr
Armco 17-7PH	17 Cr, 7 Ni, 1.25 Al, <0.09 C	Sheet, Strip	Sol H.T. at 1950 F, a.c. Sol H.T. at 1950 F, a.c., transformed at 1400 F Sol H.T. at 1950 F, a.c., transformed at 1400 F, aged 950 F, ½ hr
USS Stainless W	17 Cr, 7 Ni, 0.7 Ti, 0.2 Al, 0.07 C	Wrought	Sol H.T. at 1975 F, a.c. Sol H.T. at 1975 F, a.c., aged 950 F, ½ hr
Cooper V2B	19 Cr, 10 Ni, 3 Si, 2 Cu, 3 Mo, 0.15 Be, <0.07 C	Cast	As Cast Sol H.T. at 2000 F, w.q. Sol H.T. at 2000 F, w.q., aged 925 F
Crucible HNM	18.5 Cr, 9.5 Ni, 3 Mn, 0.35 C	Forged	Sol H.T. at 2050 F, o.q. Sol H.T. at 2050 F, o.q., aged 1350 F, 16 hr
NITRIDING STEEL			
Nitralloy N	0.25 C, 1.15 Cr, 1.2 Al, 0.25 Mo, 3.5 Ni	Wrought	Normalized at 1650 F, tempered at 1200 F Normalized at 1650 F, tempered at 1200 F, nitrided
TOOL STEELS			
Crucible PHV, Die Steel	0.27 C, 2.8 Ni, 1.15 Cr, 0.4 V, 0.25 Mo, 1.15 Al	Wrought	Sol H.T. at 1700 F, o.q., tempered 1300 F, 14 hr, o.q. Sol H.T. at 1700 F, o.q., tempered 1300 F, 14 hr, o.q., aged 950 F, 20 hr
Latrobe Cascade Die Steel	0.2 C, 0.25 Cr, 4.1 Ni, 0.2 V, 1.2 Al	Wrought	Sol H.T. Sol H.T., aged 965 F, 22 hr
POWDER METALLURGY ALLOY			
Iron-copper	Iron powder infiltrated with 15% of a Cu alloy		Infiltrated, slowly cooled Infiltrated, slowly cooled, heated at 1475 F, slowly cooled, Sol H.T. at 1550 F, quench, aged 600 F, 1 hr

NOTES:
o.q.—oil quenched; a.c.—air cooled; w.q.—water quenched.
[1] *Minimum.*
[3] *Core properties.*
[8] *Maximum.*

Iron and Steel

Although an age-hardening nitriding steel has been in use for a number of years, application of the principles of precipitation hardening to ferrous alloys, in general, is a relatively recent development. However, a number of stainless steels, several tool steels and a powder metallurgy product are now available commercially which depend on age hardening to improve their properties.

Nitralloy N

Possibly the first of the age-hardenable ferrous alloys to be employed commercially was Nitralloy N. This alloy is a nickel bearing modification of the standard nitriding steel, Nitralloy G, which contains aluminum. Steels containing both nickel and aluminum can be age hardened by prolonged heating in the range 850 to 1100 F. Since this is the range used for nitriding, the two operations proceed simultaneously. During the nitriding of Nitralloy N, yield strength of the core can be raised from 115,000 to 180,000 psi while the case is being nitrided to a high hardness value.

Stainless Steels

Until age hardening was introduced, the only method of increasing strength and hardness of austenitic stainless steels was cold-working. Fabricating in the fully-hard condition had certain disadvantages, such as springback, which were well known. Therefore, the possibilities of age hardening were investigated. Ignoring the superalloys for the moment, the most successful commercial alloys produced up to the present time are based on the 18:8 grade. Elements added to impart precipitation hardening characteristics include copper, titanium, aluminum and beryllium. The commercial steels are proprietary.

Armco produces two grades, one depending for its properties on copper, the other on aluminum. This producer has established temper designations to indicate the condition of the material. For 17-7PH:

A—annealed at 1925-1975 F, air cooled
T—condition A material transformed at 1375-1425 F for 1½ hr and cooled to 60 F or lower within I hr
TH950—condition T material hardened at 940-960 F for 30 min
TH1050—condition T material hardened at 1040-1060 F for 1½ hr
C—cold rolled
CH900—condition C material hardened at 890-910 F for 1 hr

The hardening treatments are followed by air cooling.

Other steels in this group are USS chromium-nickel Stainless W, which depends on titanium and aluminum for its aging properties and Crucible HNM a high carbon modification of 19:9. The only steel intended for use in castings in the group is Cooper V2B which owes its age-hardening properties to beryllium.

Solution heat treatment requires heating within the range 1900 to 2050 F and the manner of cooling depends on the alloy. Some require water quenching, others are sufficiently sluggish to require only air cooling to develop aging characteristics. These steels are aged at temperatures ranging from 900 to 1300 F, and in some cases require an intermediate heat treatment between the solution and aging steps.

Properties of the steels are given in a table. As an example of the improvement obtainable, suitable aging increases yield strength of USS Stainless W from 95,000 to 200,000 psi

rons and Steels

Temper	Density, lb/cu in.	Yield Strength, psi	Tensile Strength, psi	Elong, % (2 in.)	Hardness		Fatigue Strength, psi (10^7 cycles)	Izod Impact Value, ft-lb
					Brinell	Rockwell		
A	0.28	110,000	150,000	10.5	<341	—	—	—
H1000	—	160,000	170,000	14	375	C37	87,500	30
A	0.282	40,000	130,000	30	—	B85	—	—
T	—	100,000	145,000	9	—	C31	—	—
TH950	0.276	200,000	215,000	8	—	C45	—	—
—	0.28	95,000	135,000	11	—	C25	70,000	35
—	—	200,000	210,000	11	—	C43	110,000	16
—	—	—	—	—	302	—	—	—
—	—	—	—	—	269	—	—	—
—	—	122,000	152,000	3	363	—	—	—
—	—	—	—	—	<200	—	—	—
—	—	100,000[1]	140,000[1]	10	350	—	—	—
—	0.28	115,000[2]	132,000[2]	22[2]	277[2]	—	—	—
—	—	180,000[2]	190,000[2]	15[2]	415[2]	—	—	—
—	0.28	—	—	—	250[3]	—	—	—
—	—	159,000	170,000	16	365[2]	C38	—	—
—	0.275	85,000	125,000	24	262[3]	C26[3]	—	—
—	—	165,000	179,000	16	358	C38	—	—
—	—	50,000	70,000	12	—	B65	—	—
—	—	85,000	100,000	8	—	B85	—	—

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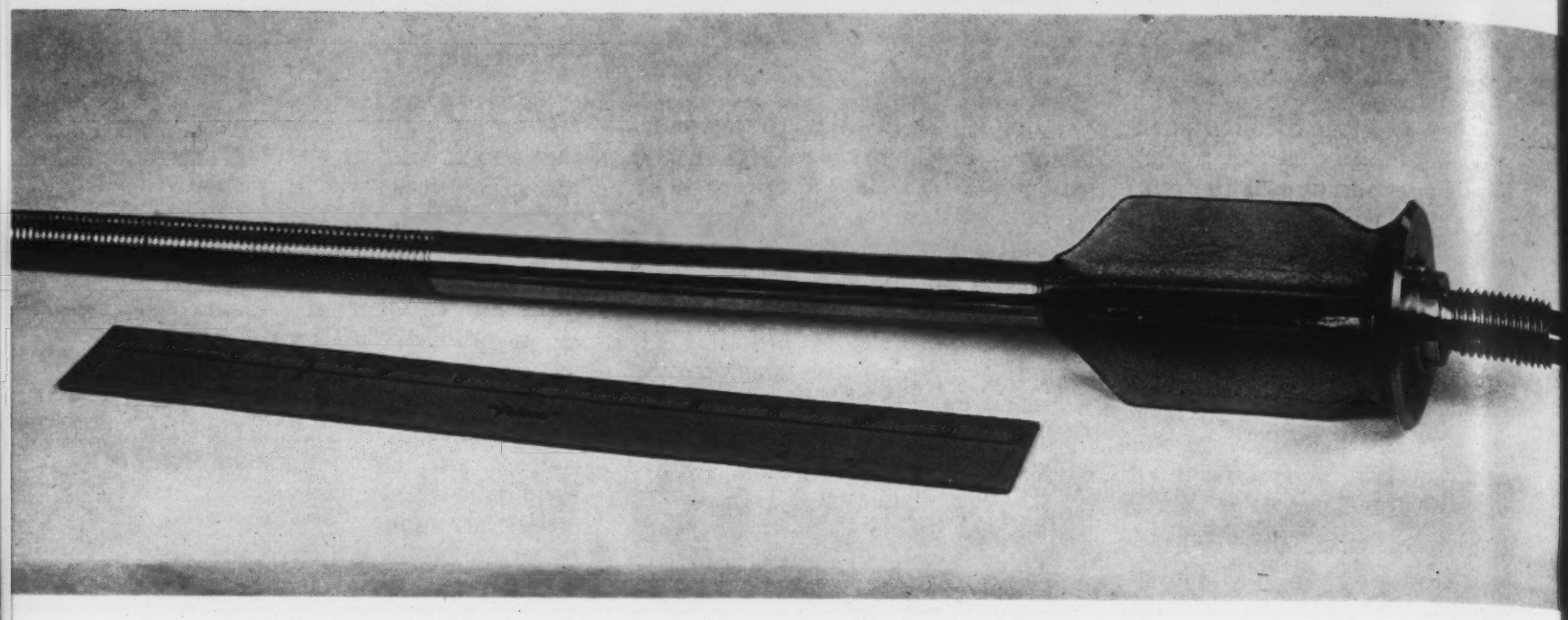


Safety valve stem for liquefied petroleum gas tank, upset and forged from Armco 17-4PH bar stock, annealed and machined. High strength was developed by a single aging treatment at 900 F.

with little loss in ductility as measured by the elongation. Cooper V2B can be hardened from 302 Brinell in the "as-cast" condition to 363 and at the higher hardness level has a yield strength of 122,000 psi. Similar improvement can be shown in the other steels mentioned.

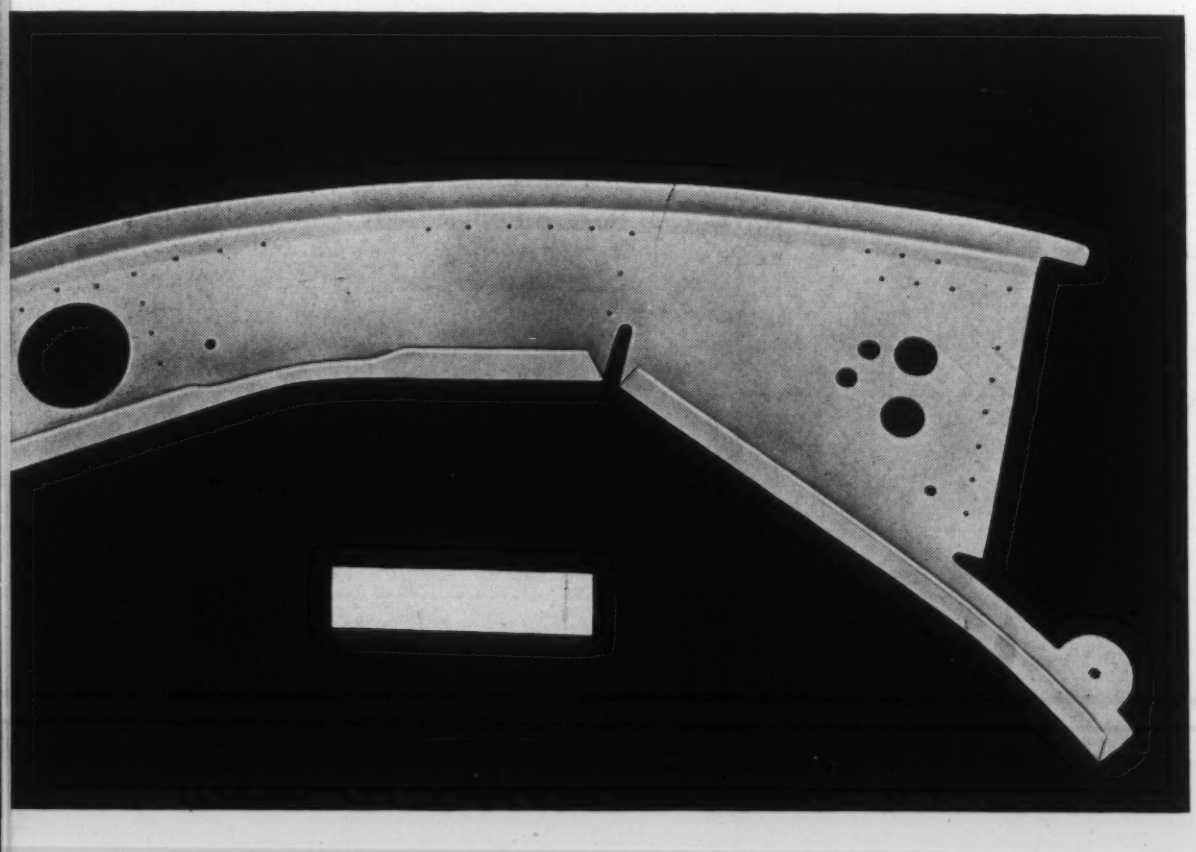
Although emphasis has been placed on the 18:8 modifications, other austenitic steels can be similarly improved. For example, Rezistal 3311, produced by Crucible, having a base composition of 21 chromium, 23 nickel, 3.25% aluminum is age hardenable.

Tool Steels

The advantages of precipitation hardening are being applied also to tool steels. In hardening a finished tool by conventional methods, there is considerable danger of distortion or cracking, particularly if a complicated shape is involved. By using steels which can be hardened by precipitation, the steel can be machined to final form in the solution treated condition in which it is quite readily machinable. Hardening is then achieved by aging at temperatures below 1000 F, with little danger of dimensional change, scaling or distortion.

At least two age-hardening tool steels are being produced commercially and others are under development. These steels, Crucible PHV and Latrobe Cascade depend on aluminum for their age-hardening properties. The steels can be solution heat treated at about 1700 F. One producer recommends a tempering treatment at 1300 F following solution. They can be age hardened by holding at 950 to 975 F for a period of about 20 hr.

Both of the steels have hardness values of about 250 Brinell in the solution treated condition. After aging, hardness increases to about 360 Brinell or Rockwell C38. In the aged condition, they have yield strengths of 160,000 psi with elongations of 16%. These steels can be nitrided to obtain surface hardness values of about Rockwell 15-N 94.



Section of fuselage frame for jet fighter plane fashioned from Armco 17-7PH by stretch forming a flanged blank. High strength is developed by 1400 F and 1050 F heat treatments with holes positioned after 1400 F treatment.

Metal Powder Parts

The age-hardening process is not limited to conventional materials. It

can be applied in the powder metallurgy field to a material which cannot be produced by melting. This alloy is prepared by forming a porous skeleton of iron by pressing and sintering an iron powder compact. The skeleton is then impregnated with a copper alloy. The copper alloy can be diffused into the iron matrix by a diffusion heat treatment. Following this step, a solution treatment at about 1550 F and aging at 600 F will increase the yield strength from 50,000 to 85,000 psi without an excessive loss in ductility.

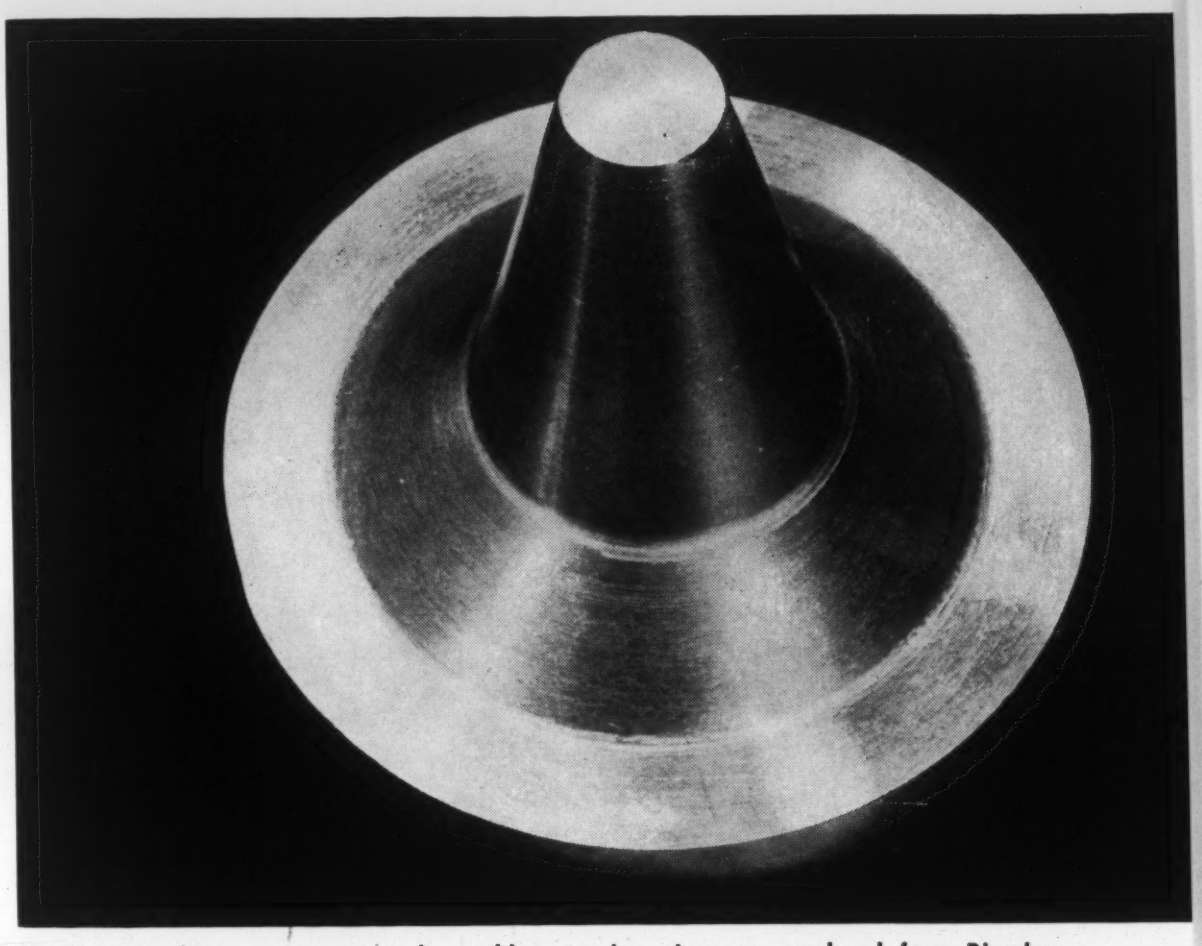
Superalloys

The superalloys are based on a solid solution of iron and chromium, contain sufficient nickel to make the alloy austenitic at room temperature, and, in addition, have part of the iron content replaced by nickel or cobalt. In some of these alloys the replacement of iron is practically complete and the alloys are nickel or cobalt base materials.

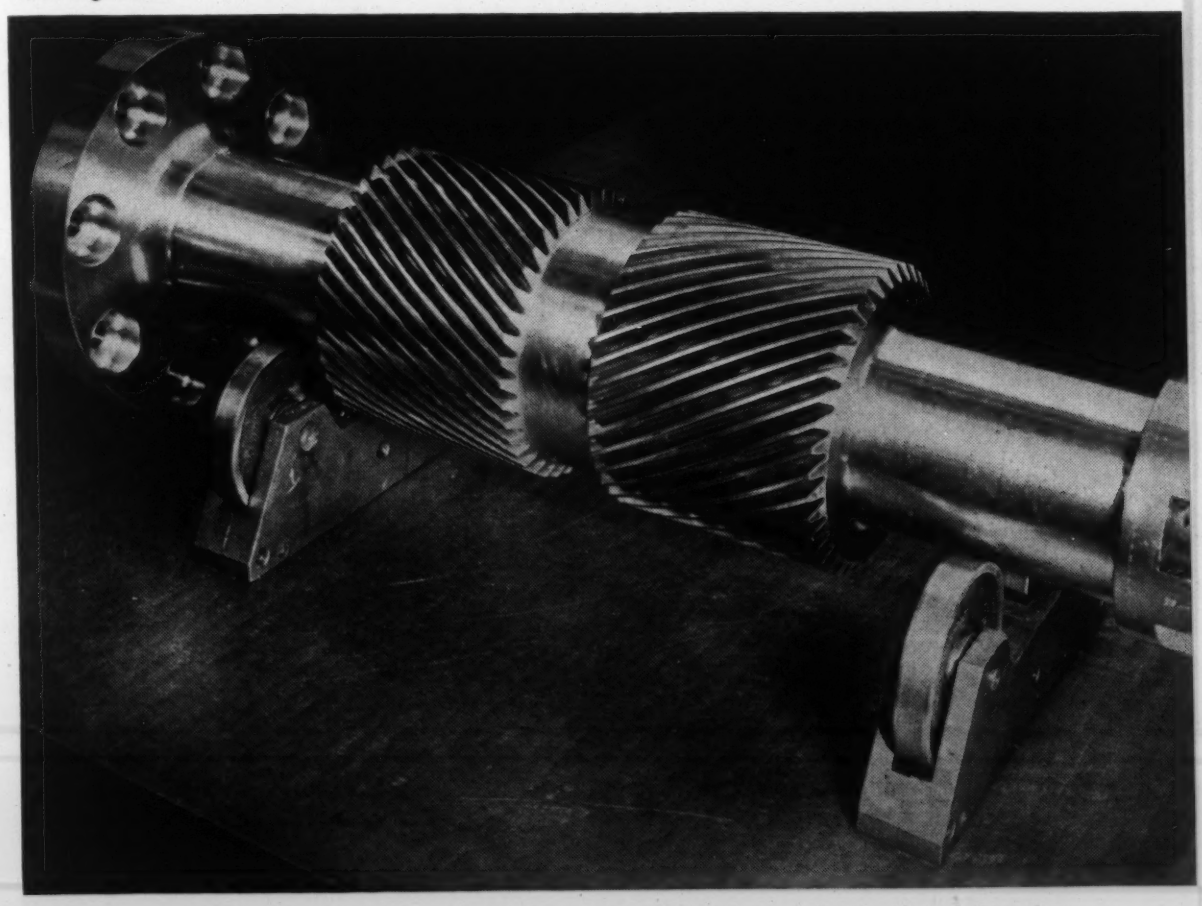
Among the alloys are a number which can be age hardened. Some of these, including Discalloy, K42B and Inconel X owe their aging properties to titanium; others, including Refractaloy 70, depend on molybdenum; while still others, including S590, S816 and Stellite 21 rely on a combination of molybdenum and carbon.

The nature of these alloys is such that they require high temperature heat treatment for solution of the precipitant. Temperatures for solution treatment lie in the range 1800 to 2400 F, but must be adjusted to suit the individual alloy. Rate of cooling after solution treatment also depends on the alloy. Some of them must be water quenched, others can be air cooled. These alloys are generally aged at higher temperatures than those discussed previously, aging temperatures lying in the range 1200 to 1500 F.

Properties of several age-hardening superalloys are included in a table. Although they vary considerably in composition, all age to roughly the same hardness level, about 300 Brinell. Most of these alloys have yield strengths around 100,000 psi in the aged condition and retain good ductility. The property improvement at room temperature is not so great as it is in certain other alloy systems, but room temperature properties are not of paramount importance in those alloys since their major field of usefulness lies in high temperature applications. Because softening by over-aging is slow in the service temperature range, 1200 to 1500 F, these alloys retain a large part of their strength for long periods of time. Thus, they are particularly valuable for service under stressed conditions at these high temperatures.



Many gas turbine components such as this extension piece are produced from Discaloy. (Westinghouse)



Machining operations on this pinion forging were performed on fully hardened Discaloy with standard tools and equipment. (Westinghouse)

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Some Age-Hardenable Superalloys

Material	Composition, %	Form	Treatment	Density, lb/cu in.	Yield Strength, psi (0.2%)	Tensile Strength, psi	Elong, % (2 in.)	Hardness	
								Brinell	Rockwell
A-286	<0.08C, 1.5 Mn, 15 Cr, 26 Ni, 1.25 Mo, 2 Ti, 0.3 V, 0.35 Al, Fe rem	Bar	Sol H.T. at 1800 F, o.q.	0.286	—	—	—	145	—
			Sol H.T. at 1800 F, aged 1325 F, 14 hr	—	100,000	148,000	25	285	—
Discaloy	26 Ni, 13.5 Cr, 3.2 Mo, 1.6 Ti, 0.1 Al, 0.03 C, Fe rem	Wrought	Sol H.T. at 1800 F	0.287	—	—	—	150	—
			Sol H.T. at 1800 F, aged 1200 F, 20 hr	0.288	106,000	145,000	19	293	—
S590	20 Ni, 20 Co, 20 Cr, 1.5 Mn, 4 Mo, 4 W, 4 Cb, 0.4 C, Fe rem	Wrought	Sol H.T. at 2270 F	0.300	—	—	—	160	—
			Sol H.T. at 2270 F, w.q., aged 1400 F, 16 hr	—	90,000	160,000	10	290	—
K42B	22 Co, 18 Cr, 14 Fe, 2.1 Ti, 0.2 Al, 0.03 C, Ni rem	Wrought	Sol H.T. at 1750 F	0.296	—	—	—	175	—
			Sol H.T. at 1750 F, w.q., aged 1300 F, 24 hr	—	105,000	158,000	29	293	—
Inconel X	15 Cr, 7 Fe, 1 Cb, 2.5 Ti, 0.7 Al, Ni rem	Sheet	Sol H.T. at 2000 F, a.c.	0.300	45,000	111,000	47	—	C8
			Sol H.T. at 2000 F, a.c., aged 1300 F, 4 hr	—	115,000	172,000	26	—	C33
Refractaloy 26	20 Co, 18 Cr, 16 Fe, 3.2 Mo, 3 Ti, 0.2 Al, Ni rem	Wrought	Sol H.T. at 2100 F, o.q.	0.296	—	—	—	200	—
			Sol H.T. at 2100 F, o.q., aged 1500 F, 20 hr, aged 1350 F, 20 hr	—	100,000	170,000	18	275	—
Stellite 21	26 Cr, 5.5 Mo, 2 Ni, 1 Fe, 0.2 C, Co rem	Cast	As Cast	0.299	82,000	103,000	8	—	A65
			Aged 1350 F, 50 hr	—	110,000	125,000	2	—	A70
Refractaloy 70	21 Ni, 20 Cr, 14 Fe, 2 Mn, 8 Mo, 4.2 W, 0.04 C, Co rem	Wrought	Sol H.T. at 2350 F, o.q.	0.313	—	—	—	200	—
			Sol H.T. at 2350 F, o.q., aged 1500 F, 240 hr	—	87,000	132,000	3	315	—
S-816	20 Ni, 20 Cr, 4 Fe, 1.5 Mn, 4 Mo, 4 W, 4 Cb, 0.37 C, Co rem	Wrought	Sol H.T. at 2200 F, w.q.	0.310	—	—	—	220	—
			Sol H.T. at 2200 F, w.q., aged 1450 F, 14 hr	—	67,000	140,000	31	310	—
		Cast	As Cast	—	—	100,000	6	—	—
			Sol H.T. at 2300 F, w.q., aged 1400 F, 6 hr	—	—	122,000	0.5	—	A70

NOTES:
o.q.—oil quenched, w.q.—water quenched, a.c.—air cooled.

Cast V2B valve disk and air compressor disk produced by Cooper Alloy Corp.

Acknowledgment

The writer acknowledges the assistance of the personnel and publications of the following organizations in the preparation of this Manual.

Allegheny-Ludlum Steel Corp.
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The Beryllium Corp.
The Brush Beryllium Co.
Chase Brass & Copper Co.
The Cooper Alloy Corp.
Crucible Steel Co. of America
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Materials Engineering File Facts

MATERIALS & METHODS
October • 1954
Number 286

Lead and Lead Alloys — Soft Lead

Lead and these alloys are used chiefly for corrosion resistance in chemical construction, cable sheathing, and plumbing; in storage batteries because of the electro-chemical properties of lead and its oxides; or in applications where its density is advantageous such as radiation protection and counterbalances.

TYPE	Chemical Lead	Common Lead (soft lead)	Tellurium Lead
COMPOSITION—%	Pb 99.90+	Pb 99.73+	Te 0.05, Cu 0.06 max
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.41	0.41	0.41
Melting Point, F	618	621	617
Thermal Cond, Btu/hr/sq ft/ft/°F at 212 F	19.6	19.6	19.3
Coeff of Exp per °F:	16.3×10^{-6}	16.3×10^{-6}	16×10^{-6}
Spec Ht, Btu/lb/°F	0.031	0.031	0.031
	—	(32 F)	—
Elect Res, Microhm-Cm at 68 F:	—	20.6	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	2×10^6	2×10^6	1.5×10^6
Tensile Str, psi:			
Rolled	2454	2093	—
Extruded	2200	2000	—
Extruded and Aged	—	—	—
Sand Cast	—	1800	—
Chill Cast	2200	2000	—
Yield Str, psi:			
Rolled	1640	—	—
Extruded	—	—	1500
Sand Cast	—	800	—
Chill Cast	—	—	—
Elong in 2 In., %:			
Rolled	57	43	—
Extruded	48	—	40
Extruded and Aged	—	—	—
Sand Cast	—	30	—
Chill Cast	40	47	—
Reduction of Area, %:			
Extruded	—	—	—
Sand Cast	—	100	—
Chill Cast	—	100	—
Hardness, Bhn:			
Extruded	—	—	6
Sand Cast	—	3.2–4.5	—
Chill Cast	—	4.2	—
Impact Str, Charpy, ft-lb:			
Extruded	—	—	—
Sand Cast	—	—	—
Chill Cast	—	10	—
Fatigue Str, (End Limit), 10^7 cycles:			
Extruded and Aged	725	470	1000
Sand Cast	—	470	—
Chill Cast	—	—	—
Shear Str, psi			
Sand Cast	—	1825	—
Chill Cast	—	1825	—
Creep Str, psi (0.1% per year)			
Rolled	300 (85 F)	250	300
FABRICATING PROPERTIES	← Formed by cold rolling and extrusion →		
Casting Temp Range, F:	790–850	790–850	790–850
Joining	Soft solder with 50–50 or 40–60 solder using rosin or stearic acid flux; oxy-hydrogen welding (lead burning) slightly reducing flame; no flux.		
CORROSION RESISTANCE	Resistant to sulfuric, sulfurous, phosphoric and chromic acids; attacked by acetic, formic and nitric acids; resistant to the atmosphere, fresh and salt water.		
AVAILABLE FORMS	Cast, rolled, extruded, ingot		
USES	Chemical apparatus	Storage batteries, cable sheath, ammunition, caulking, alloying, coatings, liquid baths for heat treating.	Chemical apparatus

Prepared with the assistance of the Lead Industries Association, and The American Smelting and Refining Company

For more information, Circle No. 301

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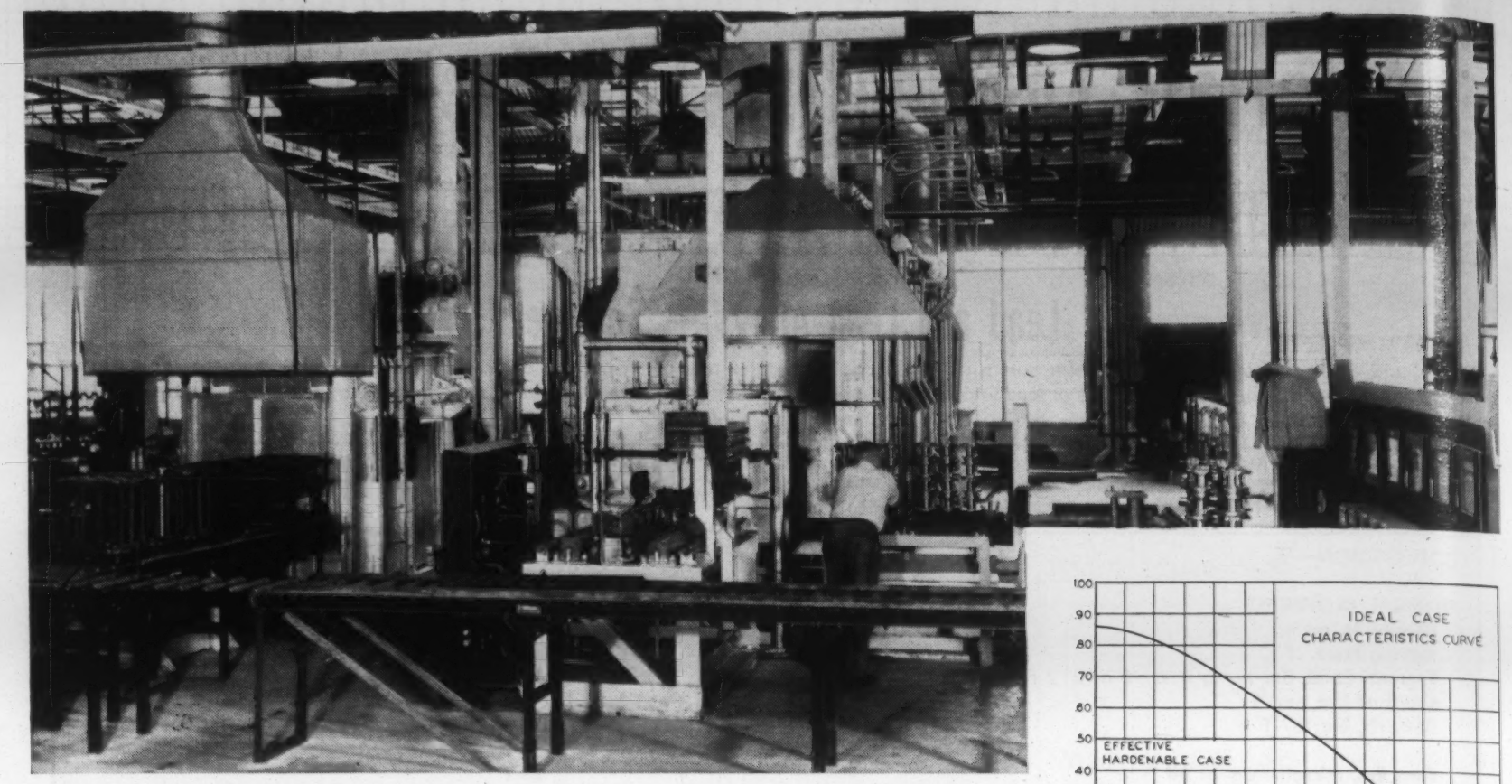
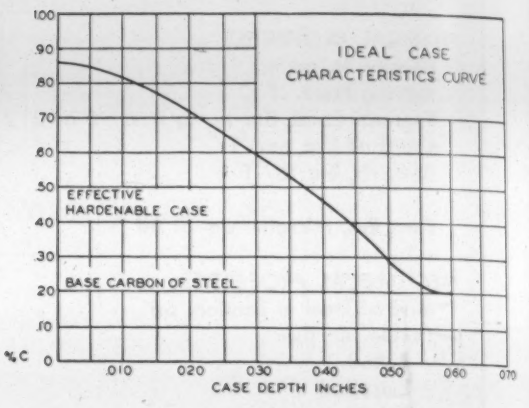
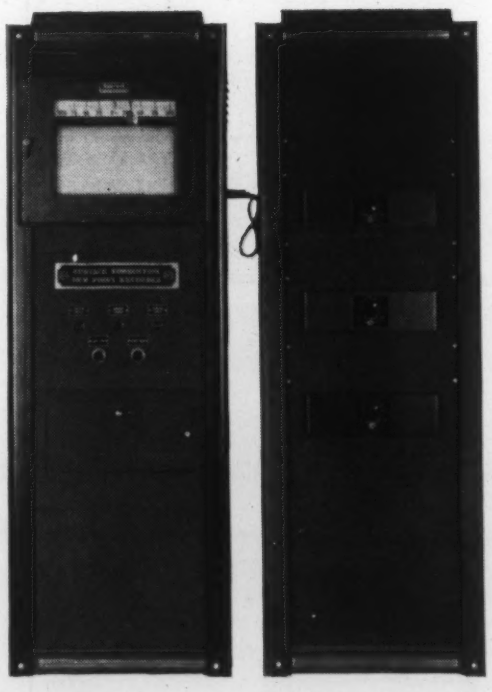




on the nose every time

WITH SURFACE AUTOCARB AUTOMATIC CARBON POTENTIAL CONTROL



New high physicals in carburized gears—better tooth-to-tooth and gear-to-gear uniformity—faster cycles—automatic compensation for changes in work surface area during furnace operation . . .

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Materials Engineering File Facts

MATERIALS & METHODS
October • 1954
Number 286

Lead and Lead Alloys — Hard Lead

Properties of antimonial lead alloys may vary considerably depending upon temperature, rate of cooling and time of aging.

TYPE	1% Sb-Lead	Hard Lead	Hard Lead	8% Sb-Lead	Grid Metal (7-12 Sb)
COMPOSITION—%	Sb 1	Sb 4	Sb 6	Sb 8	Sb 9
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.406	0.398	0.393	0.388	0.385
Melting Range, F	608–595	570–486	545–486	520–486	509–486
Thermal Cond, Btu/hr/sq ft/ft/°F, at 212 F	19	18	17	16	16
Coef of Exp per °F: 68-212 F	16×10^{-6}	15.5×10^{-6}	15.4×10^{-6}	14.5×10^{-6}	14.4×10^{-6}
Spec Ht, Btu/lb/°F:	0.031	0.032	0.032	0.032	0.032
Elect Res, microhm-cm at 68 F:	22	24	25	26.5	27.1
MECHANICAL PROPERTIES					
Mod of Elasticity in Tension, psi	2×10^6	—	—	—	—
Tensile Str, psi					
Extruded	2920	3100	3300	3330	—
Extruded and Aged	3000	—	—	—	—
Rolled	3050	4020	4100	4650	4700
Chill Cast	3400	5660	6840	7420	7400
Elong in 2 In., %:					
Extruded	58	58	65	75	—
Extruded and Aged	50	—	—	—	75
Rolled	60	48	47	31	17
Chill Cast	16	22	24	19	—
Hardness, Bhn:					
Extruded	5.1	8.9	10.7	12.4	—
Extruded and Aged	7	—	—	—	—
Rolled	5.9	8	—	9.5	7.8
Chill Cast	7	10	11.8	13.3	15.4
Fatigue Str, (End Limit), psi 2×10^7 cycles:					
Extruded	—	—	1200	—	—
Extruded and Aged	1150	—	—	—	—
Rolled	—	1500	1500	1750	—
Chill Cast	—	—	2500	—	2700
Creep Str, (86 F) (1% Ext in 10,000 Hr)					
Extruded	350	210	—	—	—
Rolled	—	250	400	425	400
FABRICATING PROPERTIES					
Casting Temp Range, F	750–925	750–925	750–850	750–925	750–925
Joining	Soft solder with 50–50 or 40–60 solder using rosin or stearic acid flux; oxy-hydrogen welding (lead burning) no flux, slightly reducing flame.				
CORROSION RESISTANCE	Similar to that of soft lead				
USES	Cable Sheathing	Rolled sheet for roofing and flashing; extruded pipe for corrosion resisting applications requiring greater strength than soft lead.			Battery grids

Prepared with the Assistance of the Lead Industries Association, and The American Smelting and Refining Company

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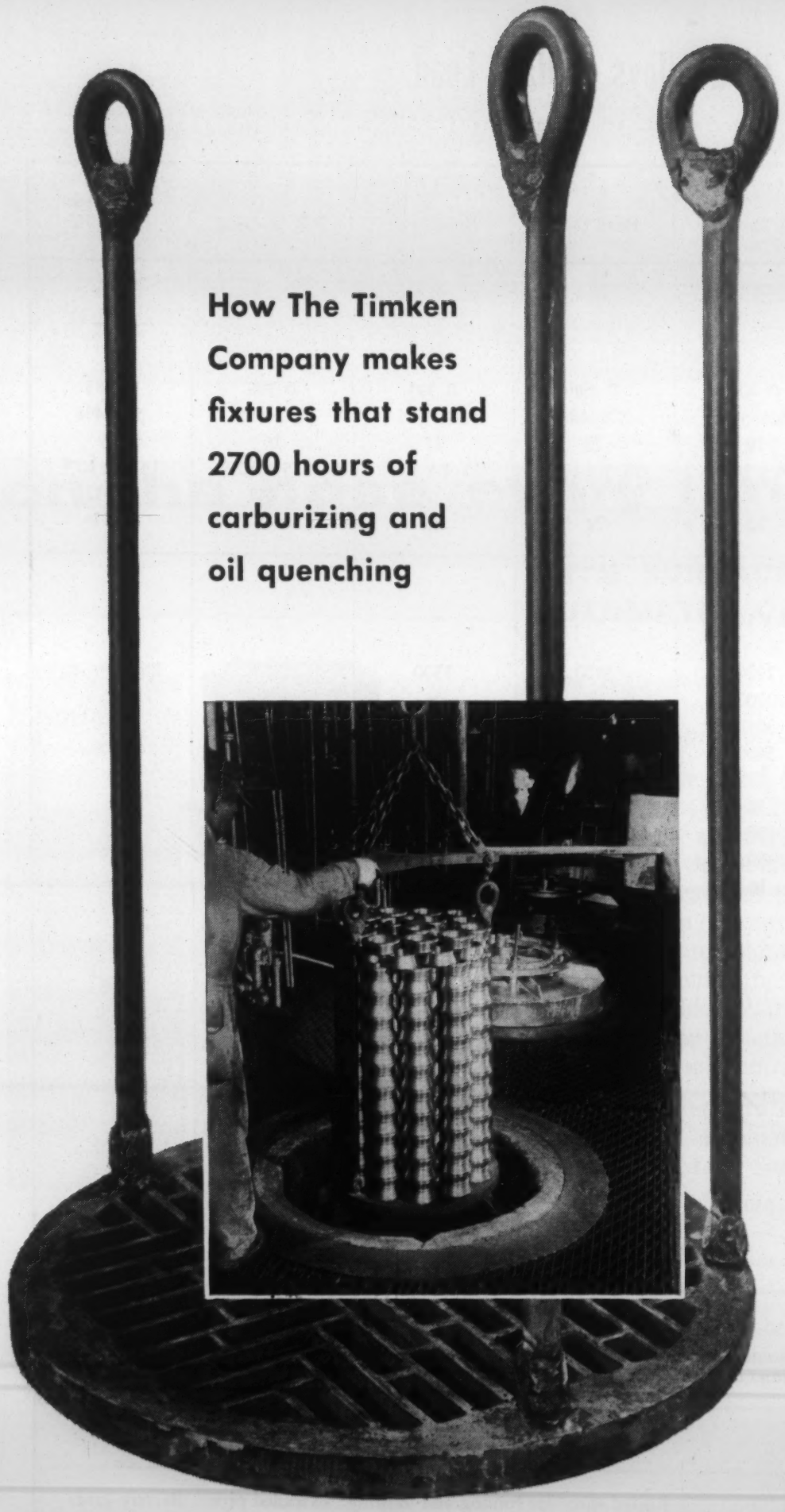
Service life doubled ...with Inconel



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Roller bearing parts at The Timken Company are carburized in natural gas. This heat treatment is followed by an immediate oil quench.

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Materials Engineering File Facts

MATERIALS & METHODS
October • 1954
Number 287

Relative Strengths and Densities of Some Engineering Materials

Material	Tensile Strength, Psi	Compressive Strength, Psi	Density lb/cu ft	Specific Gravity
Aluminum	9000–24,000	10,000	165	2.6
Balsa Wood	*	2150	7.9	0.128
Brass, Common Yellow	50,000–90,000	*	524	8.47
Cement-Asbestos Board	*	16,000	103	1.63
Concrete	None	2400	144	2.3
Cork Board	10–15	15	9.9	0.16
Glass Matt Reinforced Laminate	25,000	20,000	100	1.6
Galvanized Steel	40,000–110,000	50,000–80,000	490	7.8
Glass (plate)	650	36,000	160	2.5
Honeycomb Cores				
Aluminum Foil	Depends on faces	220–920	2.9–11.0	0.05–0.17
Cotton Fiber	Depends on faces	380–1000	4.7–8.6	0.07–0.13
Fiberglass	Depends on faces	*	1.0–11.4	0.01–0.18
Paper	Depends on faces	140	1.8–2.2	0.03–0.04
Lead	26,000–3300	7500	710	11.37
Magnesium	12,000–37,000	*	108	1.74
Micarta	11,000	38,000	84	1.35
Neoprene	500–3500	475–3000	81–187	1.3–3.0
Novoply	775	*	36	0.58
Plywood				
Fir (parallel)	6180	5150	29.9	0.48
(perpendicular)	3910	3440	29.9	0.48
Luan (parallel)	6390	5150	31.4	0.58
(perpendicular)	3780	3440	31.4	0.58
Porcelain Enamel	650	36,000	160	2.
Stainless Steel				
302	80,000	60,000–100,000	490	7.8
430	60,000	60,000–100,000	490	7.8
Tin	2000–3000	*	458	7.3
Zinc	20,000–30,000	*	446	7.1

NOTE: Data are approximate—for rough comparison only.
** No data.*

Courtesy of United States Plywood Corp.

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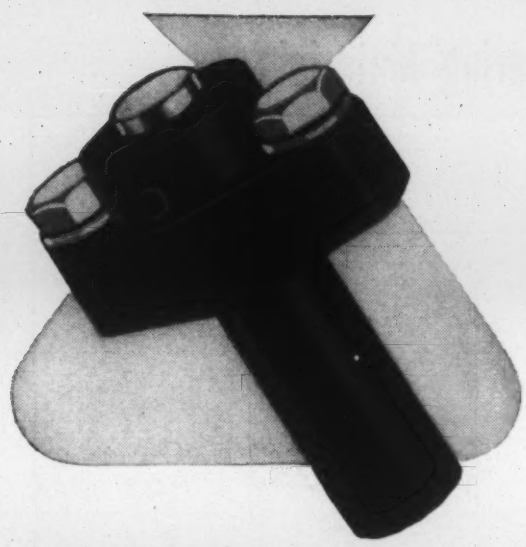
Du-Lite

"Gives our tools Sales Appeal"



BARNABY MFG. CO. of Bridgeport, Conn., reports: "Our close proximity to salt water has given us problems in rust prevention for many years. We have experimented with many black oxide finishes but none has proven as successful, safe, and inexpensive as DU-LITE—our tools have better sales appeal—our volume has been on the increase ever since we started using this modern, progressive oxide finish."

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- SD Compound for removing occluded salts.
- Phosteel and Phospray for phosphatizing steel, iron or zinc.
- Du-Lite Non-Acid Black Oxide for copper and copper alloys.
- Dynakleen for bright cleaning all metals.
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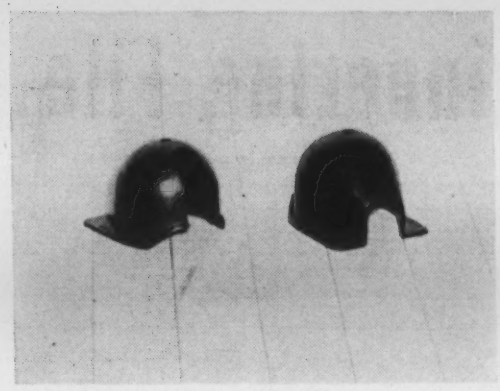
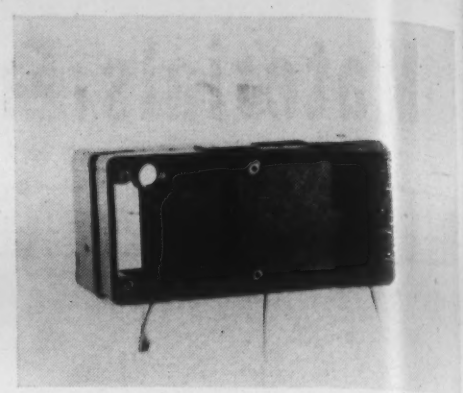
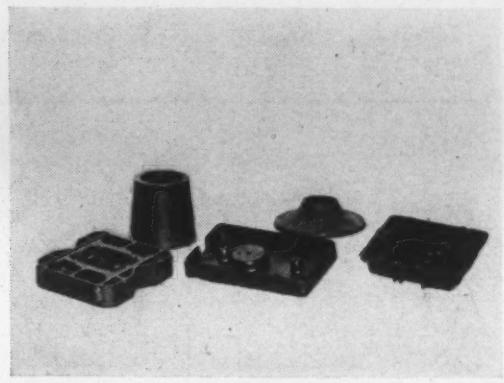
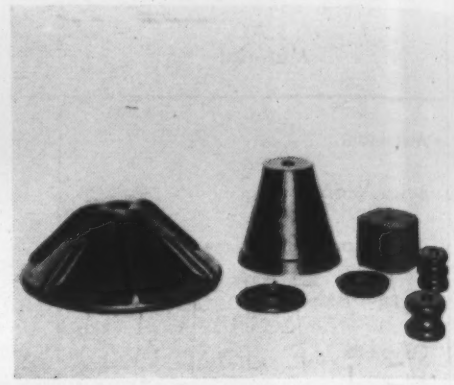




***AUTOMOTIVE** uses of asbestos-asphalt materials include hand brake cable cover (left) and automotive battery voltage regulator (right). Note molded-in inserts.*





***PLUGS**, bases, stands (left) and underground anchors, tubes, and knobs (right) are a few of the diverse applications of these injection molding materials.*

—A Low Cost Injection Molding Material

by **KENNETH ROSE**, Mid-Western Editor, Materials & Methods

These thermoplastic materials composed of asbestos fiber and a binder of asphalt or resin, have good corrosion resistance, but relatively low strength.

● A GROUP OF MOLDING MATERIALS consisting of a fibrous or granular filler and a binder has been classed as plastics for many years. They are plastics only in that they are moldable at some stage in their processing. Chemically they are distinct from the compounds that obtain their special properties by being polymerized to high molecular weight. These materials have usually been designated as cold molded materials.

Several materials of this general type have been developed by Plymouth Industrial Products, Inc. for producing custom molded products. They consist of short-length asbestos fiber with a binder of asphalt or resin, the ingredients being combined in approximately equal proportions. The proportions are varied to obtain

a range of rigidity in the molded parts. Of considerable importance from a cost and processing standpoint is the ability of the material to be molded on modified injection molding machines, with a short cycle, so that molding costs are held to a minimum.

Properties

The materials, offered under the trade names Clevelon for the asphalt binder type and Bartalon for the resin binder type, have excellent resistance to mild acids, mild alkalies, salts, weathering and moisture. They have low to medium strength compared to other plastics and good impact strength. Impact strength at low temperatures is usually as good as or better than that at room temperature. Strength at elevated temperatures under load is limited, but in many designs this can be improved by reinforcing with metal inserts. It will withstand temperatures to 160 F, and in many cases parts have successfully withstood higher temperatures at light loads for short periods.

Some oils and most organic solvents will attack the surface of the molded material. It can be painted, or coated with other types of finishes, or may be upholstered. The material can be machined without difficulty, drilled at high production rates if high speed drills are used, and sawed without dulling the saw excessively. Use of a saw with coarse teeth or with too great a set may cause a slight chipping of the surface of the work.

Results of various immersion tests with the material are given as follows:

Sulfuric acid absorption
(48-hr in 2-normal acid): 0.03% weight increase, no change in appearance

Calcium absorption
(24-hr immersion): 0.09% weight increase, no change in appearance

Oil absorption
(48-hr immersion): 0.18% weight increase, no change in appearance

Water absorption
(24-hr immersion): 0.9% weight increase, no swelling in pieces tested

The materials have a fair thermal conductivity, and show reduced condensation of water vapor. Dielectric strength is good, though arcing resistance is rather low. Underwriters' Laboratories have tested insulators made of the material, and it has been reported acceptable for tube and knob wiring. Underwriters' reports upon the insulators were issued Feb. 26, 1948, and Nov. 28, 1949, reporting conformity with the National Electrical Code.

The asphalt-containing material is combustible, but is self-extinguishing. The resin-bonded type is lighter in color, and has a wider range of color possibilities. Specific gravity of both types of materials is 1.3 with some formulations slightly lighter.

Low cost is one of the most important features of the materials. While price naturally varies with the complexity of the part being molded, and with size and other handling factors, molded pieces may cost as low as 16¢ a pound or generally in the range of 1¢ per cubic inch of molded product, depending on size of part, thickness of walls, etc.

Applications

Applications are quite diversified. Many of them have to do with mechanical space filling supports in packaging or other protective applications, where the support is required to possess moderate mechanical strength in compression. Many packaging supports for military goods use the material. In casing a 90-mm projectile, special formed supports are used for the nose. The asbestos-asphalt material is used to make these supports. A closing plug seals off the cartridge case on separable ammunition in the 6- to 8-in. size range. These plugs are molded of the same type composition. Bazooka rocket nose supports replace wood turnings.

The material flows well in the molds, and large-sized pieces such as window frames and sash, are made of the molding composition. Units of this type are now being offered for homes, farm buildings, industrial buildings and commercial structures. They have rust and rot resistance, weatherproofness, resistance to chemical atmospheres, freedom from thermal shrinkage and expansion, resistance to attack by termites and fungi, and avoidance of the need for painting as some of their most important advantages.

Because of its immunity to most corrosive influences, the material is being studied for concealed structural applications. Heavy conduit for telephone wires is being produced in a 4-in. diameter for use in large buildings.

An interesting application is its use for replicas of old-fashioned street lamps for communities that wish to preserve a traditional appearance. The low cost lamp posts and the frames for lamps are molded of black material that resembles the iron lanterns in appearance, but have free-

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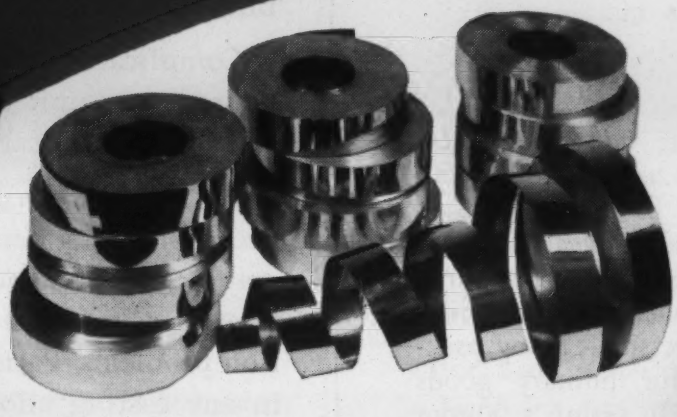

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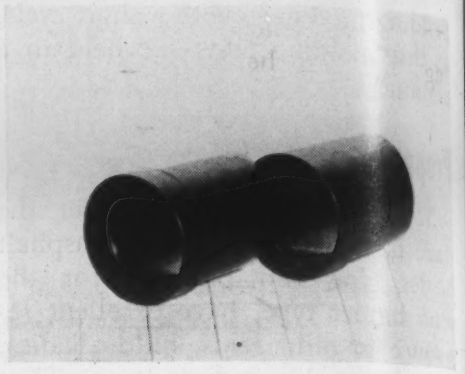
Injection Molding Material . . .

(continued from page 145)



PIPE for heat ducts and sewer pipe can be made in 3-ft lengths or longer.

dom from corrosion and light weight in handling and erection as additional features.

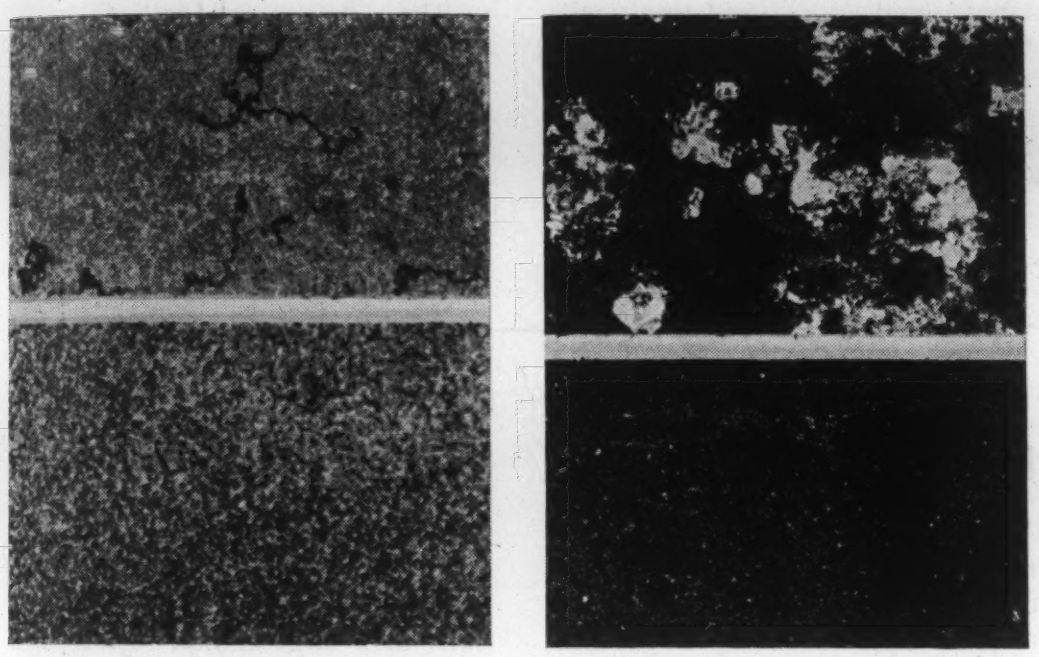
The automotive industry makes use of asbestos-asphalt moldings. An example of these is the door sill support that fits under the metal bead below the door, and serves as a sealer and as a resilient support. These pieces are molded as strips with indentations to correspond to the configuration of the metal, and are made in right- and left-hand sets. The recess into which they fit has a slight curvature, and the strips must retain enough flexibility to conform to the shape of the recess. An added time-saving feature of their handling is that the strips are packed in shipping containers while hot, just as they come from the press, and retain enough tackiness so that they may be picked up as a strip. The individual strips pull apart without damage, and may be placed under the metal beading by hand.

Electrical insulators in many styles is an important application. Wheels for toy wagons and similar moving toys are typical of the large-quantity, low-cost articles for which the material is well suited. Small pots for plant nurseries, to replace clay pots, are a standard line. Planters for domestic use are ornamented with silk-screen decoration and sold in the low-cost market. Picture frames, molded to resemble carved wood and colored and ornamented, are other consumer items for which the material has proved to be quite satisfactory.

In all of its uses, both industrial and for the consumer, the material is a low-cost molding composition with properties completely satisfactory for many purposes, and it captures its markets on this basis of satisfactory performance at lowest possible cost.

New Materials, Parts and Finishes

. . . and Related Equipment

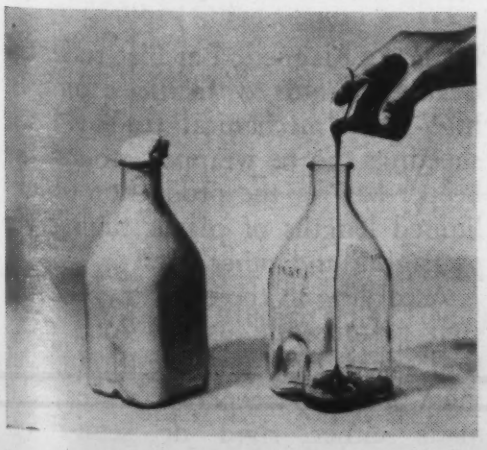


At upper left, magnesium sheet normally treated shows pitting after 25-hr salt spray. Magseal processed sheet, below, withstood 98-hr salt spray. H alloy casting at upper right failed at 32-hr salt spray, while Magseal treated casting below withstood 125 hr.

Magnesium Corrosion Resistance Increased by Impregnation

Susceptibility of magnesium to corrosion has restricted the use of that light metal to a degree. A new impregnating method for both sheet and castings is claimed to increase the corrosion resistance of the metal three or four times over normally treated magnesium. It is said to be particularly effective where dissimilar metals contact the magnesium.

Called Magseal, and developed by *Nu-Line Plastic Impregnating Co., Inc.,* 3457 E. 15th St., Los Angeles, the material is a resin combination which impregnates the metal much as conventional impregnants do. Polymerization is carried out in a pressure bake oven at 275 F, under 100 psi pressure. Upon removal from the oven, all parts are stripped of any impregnant remaining on the surface in an alkaline solution. The resin is said to be formulated for complete penetration into the smallest of pores in the metal and yet have sufficient body to seal the more spongy areas in magnesium castings. Impregnated test samples were subjected to continuous salt spray for periods up to 125 hr, and according to the company, there was no evidence of pitting or failure.



Upon addition of a liquid catalyst, the resin foams to a predetermined density.

Foam-In-Place Plastic has Varying Bulk Density

A newly developed foam-in-place thermosetting plastic is supplied as a liquid and expanded by the addition of a catalyst to a predetermined bulk density ranging from 2 to 26 lb per cu ft. Called Eccofoam FP, and developed by *Emerson & Cuming, Inc.,* 869 Washington St., Canton, Mass., the material can be processed completely at room temperature to form the rigid, unicellular foam. Since a low exothermic temperature is developed, it is possible for volumes of several cubic feet of the material to be foamed at one time.

Properties of the foam will vary with the density; however, for a material with a 10-lb per cu ft density, typical properties will be compressive strength, 340 psi; modulus of elasticity, 11,000 psi; dielectric constant, 1.18 and dissipation factor, 0.0004.

Suggested uses for the material include light-weight structural reinforcement, core material for double walled glass fiber laminates and for embedding electronic components and circuits.

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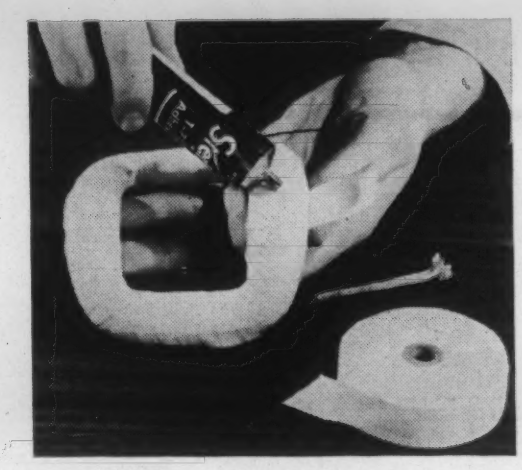
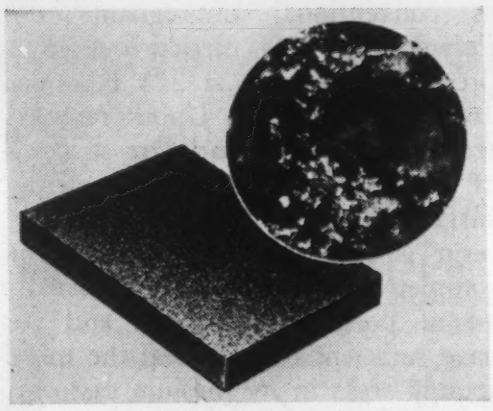


Vinyl adhesive bonds varnished cambric for insulating coils.

Solvent-Resistant Adhesive Bonds Electrical Tape

A new adhesive containing vinyl resins is said to resist varnish solvents, making it an effective bonding agent for glass mica, varnished cambric, and other varnish-saturated tapes used for insulating coils. Called Sterling T-723, and produced by the *Sterling Varnish Co.*, Haysville Borough, Sewickley, Pa., the material is said to possess good resistance to petroleum and coal-tar solvents, precluding loosening of tape bonded with the material when dipped in varnish. When the varnish is baked on, the bond is strengthened by the heat.

The adhesive is supplied in collapsible tubes containing about 1 or 2 oz of the material. For large-scale applications, it may be furnished in pint, quart, gallon or 5-gal cans in a slightly lower consistency.

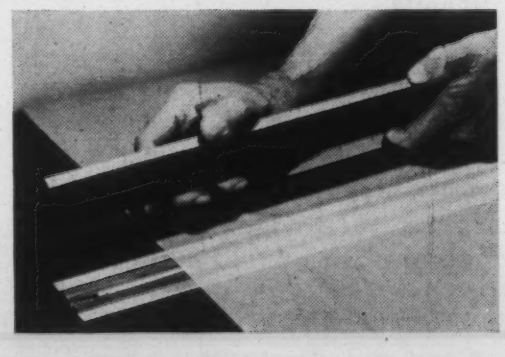


Inset shows high porosity of new fine grained carbon.

Porous Carbon has Fine Grain

A porous carbon with extremely fine grain is 75% air, yet retains characteristics such as high electrical conductivity, resistance to chemical attack, and stability at high temperatures, according to the manufacturer, *Stackpole Carbon Co.*, St. Marys, Pa. Supplied in block or sheet form, the material is said to offer interesting possibilities for impregnation or for use as filter plates. Its fine grain results in a large carbon surface area despite the high porosity of the material. The carbon is available in sizes up to around 10 by 10 in. and of any thickness up to 1½ in.

Magnetic Electrode Welds Plastic Sheet



Keeper bar is drawn down on electrode by magnetic coils to seal plastic sheet.

The combination of a radio-frequency electrode, a steel magnetic structure and a keeper bar is said to eliminate the need for a press for some types of joining operations involving plastic sheet. Magnetic coils, mounted under the electrode, draw the free keeper bar down against the plastic seam lying against the electrode. The pressure of the bar against the plastic can be adjusted by altering the voltage through the coil circuit actuating the magnet.

Developed by the *Electronic Processes Corp.*, 1156 San Antonio Rd., Los Altos, Calif., and called the Ectromag Magnetic-Bar Electrode, the device is said to facilitate simple, high-speed mechanical feeds. Plastic sheetings can be wrapped around the keeper bar for the production of unlimited lengths of plastic tubing for packaging and other uses.

According to the company, the design permits the use of long electrodes with even pressure throughout their length. Keeper bars may be made either rigid or semi-rigid. Standard sizes of the units are not listed since each installation must be tailored to the requirements of each application.

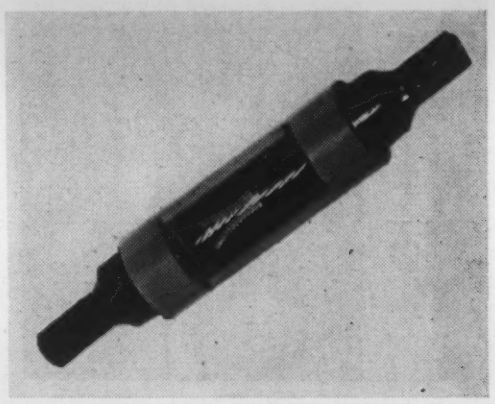
Kit With New Epoxy Resin Aids Field Splicing of Cable

Field splicing of metal cable can now be done with liquid epoxy resin, and the resultant splice is a hermatically sealed casting. No heat is required. A new electrical embedding resin, Scotchcast No. 4, developed by *Minnesota Mining and Mfg. Co.*, 900 Fauquier St., St. Paul 6, Minn., is the basis for the splicing kit. It is supplied in a plastic mixing envelope which ensures proper proportions of resin to hardener. The resin has excellent adhesion, resistance to moisture, oil, solvents and weathering and is self-extinguishing. Its average electrical properties are as follows:

Dielectric Strength, v/mil	800
Dielectric Constant at 85 F	7.2
Dissipation Factor at 85 F	0.019
Electrolytic Corrosion Factor	1.0

All the materials necessary for making a complete cast splice in single conductor cable from wire sizes 10 to 4 AWG are included in the kit. No tools other than a pocket knife are necessary. The kit includes a supply of resin and hardener in the plastic bag, a 3-piece vinyl plastic single-use mold; 2 different sized Scotchlok electrical spring connectors; a strip of abrasive cloth for cleaning the conductor; and an instruction sheet.

To make a splice, the mold pieces are slipped on the ends of the wire, the insulation penciled down, and the spring connector turned on with the fingers. After pulling the plastic mold units into place over the connection, the inner partition of the plastic resin bag is ruptured by squeezing, and the resin and hardener thoroughly mixed by kneading the bag. When the resin assumes a uniform color, a corner is snipped off the envelope and the activated resin poured into one of the spouts of the mold. The resin sets up within 5 to 15 min. The entire operation is said to take from 10 to 20 min.



Cross-section shows solid epoxy casting sealing the spring connector and cable splice.

Paint-On Zinc Coating Protects Metals

A zinc protective coating which can be used over rusted surfaces and is said to prevent rust creep has been marketed by the *Constad Laboratories*, 214 W. 29th St., New York 1. The material, called Zinktron, can be applied by brush or spray. According to the company, the coating will withstand 1000-hr salt spray and will cling to the coated material with a high degree of adhesion. Zinktron No. 2 is especially designed for abrasive use and is expected to find application in farm machinery.

The coatings are said to provide resistance to fresh water up to 212 F, and to dry heat from —40 to 350 F. They also provide good resistance to chemicals, gasoline, oils and greases.

Zinc protection is applied with a paint brush.

Silicone Gives Grease Wide Temperature Range

A new protective grease, said to be relatively unaffected over a temperature range of —70 to 400 F has been developed as a lubricant for car door weatherstrips, hood lacings, hood bumpers and all other rubber parts that require lubrication. Based on the *General Electric Company's* SF-96 silicone fluid, the grease, K2 Protective Compound, was developed by the *Jill Mfg. Co.*, Revere, Mass.

The material is water-repellent, chemically inert and is said to minimize checking and cracking of exposed weatherstrip. According to the company it keeps rubber soft and pliable and has no swelling effect. K2 is also expected to find many applications in industry, in the home, and in marine installations where moisture, sticking and chafing are problems.

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The coating is applied with spray gun, and easily stripped off after soiling.

Strippable Coating Aids Paint Booth Cleaning

A white-pigmented vinyl strippable coating helps keep industrial paint spray booths clean, and aids in obtaining better finish on the painted products, according to the manufacturer, the *Detrex Corp.*, Detroit 32, Mich. Called White Vincote, the material dries almost immediately after application to a tough, white film. Paint, lacquer and enamel overspray can be peeled off with the strippable Vincote after painting.

According to the manufacturer, the dried coating is a poor base for combustion, and the white color increases light reflectively, allowing the painter to get a better finish and minimizing chances of incomplete coverage. The material is used as-delivered, and the white pigment developed by the company is said to remain in mechanical dispersion indefinitely without stirring or agitating. The resultant film is said to have improved tensile strength, reducing possibilities of breaking away from the walls under dirt-load conditions. The material is also said to eliminate pin-holes and "blushing" or "dusting" of the dried film. One gallon of the Vincote may be expected to cover between 250 and 400 sq ft of surface, according to the thickness desired.

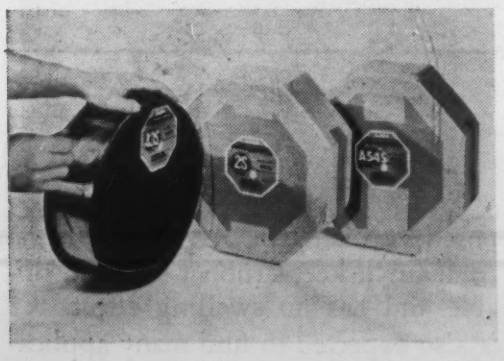
Epoxy Adhesive Bonds a Variety of Materials

A new general purpose adhesive based on epoxy resins has been developed for the bonding of materials such as glass, all metals, concrete, ceramics, wood, and almost all plastics including rigid vinyls, reinforced polyesters, phenolics, polystyrene, acrylics, cellulosics, melamines, ureas and nylon. It will not adhere to polyethylene, or the fluorocarbon resins.

Shear and tensile strengths greater than 3000 psi can be obtained with most of the above materials, according to the manufacturer, the *Atlas Mineral Products Co.*, Mertztown, Pa. In the case of wood, concrete, ceramics and laminated plastics, failure under shear or tension is said to occur in the materials themselves rather than in the glue.

Called Amphesive 801, the material contains no volatile solvents and has low shrinkage on setting, allowing it to be used to advantage as a void filler or potting compound. The material is not resistant to strong acids or alkalies. Where chemical resistance is required a special formulation, Amphesive 802, is available; however, it has poorer adhesion to glass, porcelain and other glazed surfaces. High adhesion is developed with the 801 within 24 hr at 77 F. This cure time may be shortened by heating to 190 F.

New Aluminum Welding Electrode

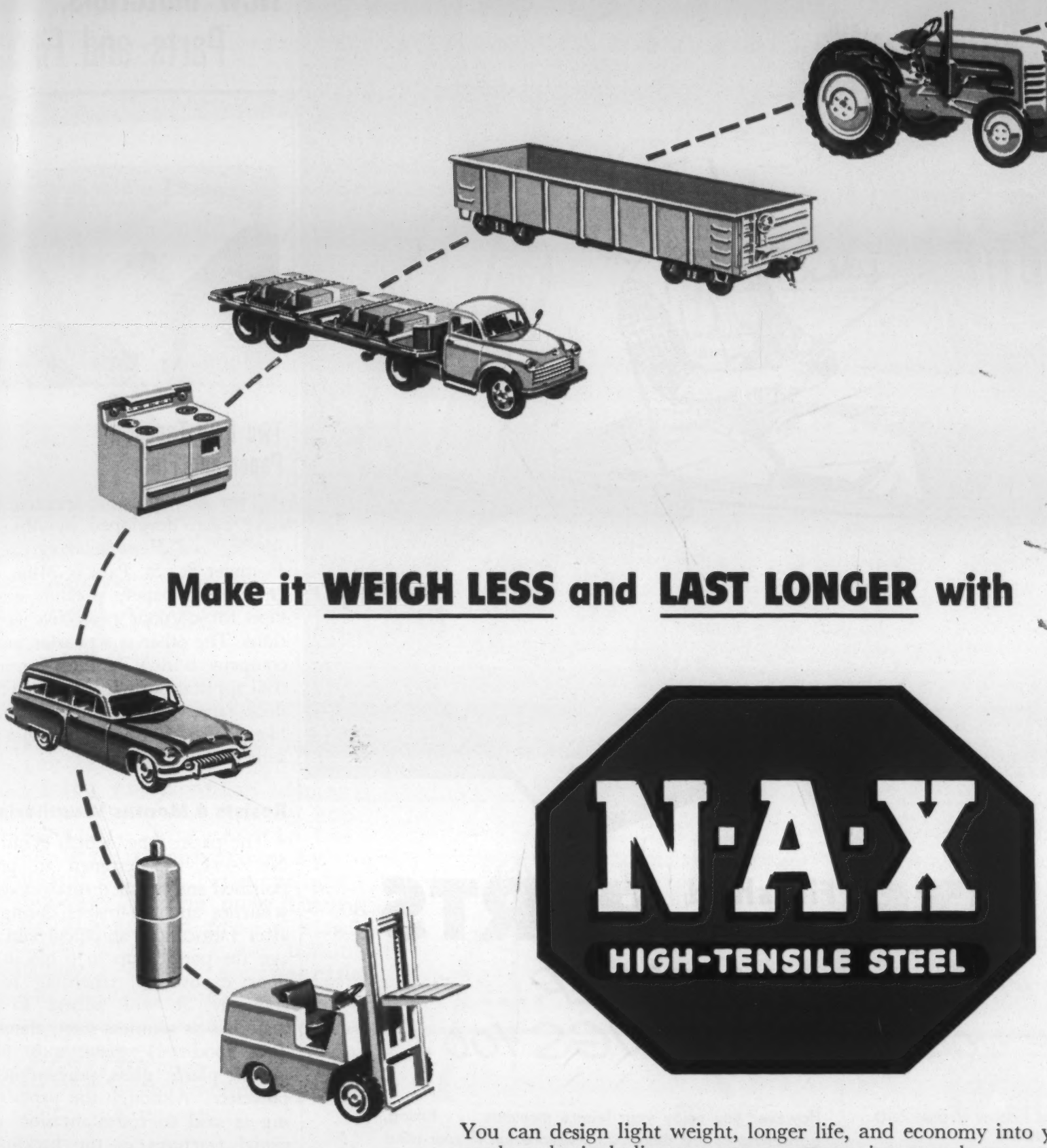


The new electrode is stocked on fiber spools containing 10 lb of wire.

A new welding electrode designed for maximum weld quality in the inertgas shielded arc welding of aluminum has been developed by the *Aluminum Co. of America*, 738 Alcoa Bldg., Pittsburgh 19, Pa. Called Alcoa I. G. Welding Electrode the consumable electrode has been designed for use in welding guns for such processes as Aircomatic, Filler-arc and Sigma. It can also be used for tungsten-arc welding where filler wire is fed mechanically to work.

The electrode is currently being produced from 1100 (2S), 4043 (43S) and 5154 (A54S) alloys. It is available in standard sizes of 0.030, 0.040, 3/64, 1/16, 3/32 and 1/8-in. dia. Mill quantity orders are available in all wire sizes from 0.020 to 1/8 in. Each spool contains 10 lb of wire level-wound in continuous length. The electrode conforms with AWS specification A5.10-54T (tentative 3/17/54) and ASTM B-285-54T.

(More New Materials on page 154)



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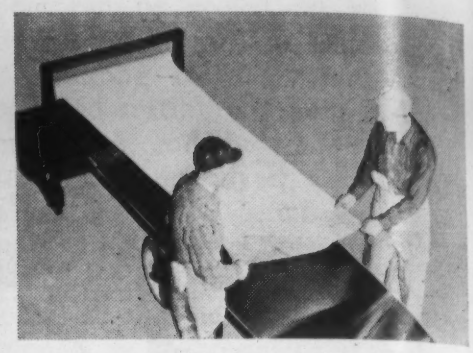


Two New Tapes; Paper and Fiber

Two new pressure-sensitive tapes have been developed by *Minnesota Mining and Manufacturing Co.*, 900 Fauquier St., St. Paul 6, Minn. One is a black paper, pressure-sensitive tape for outdoor protective applications. The other is a puzzler, and the company is now looking for industrial applications. It is a Scotch brand flock tape with an untreated suede-like fiber backing coated with a pressure-sensitive adhesive.

Resists 6 Months Weathering

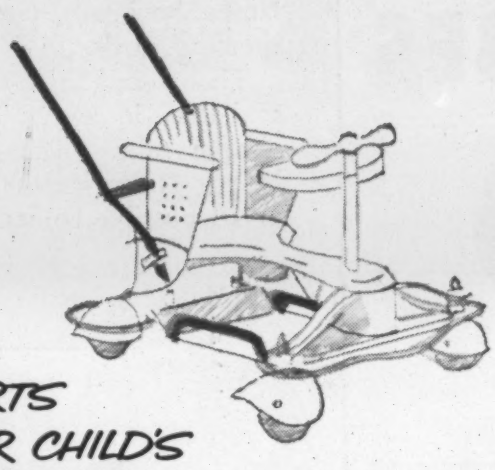
The paper tape, Scotch brand tape No. 344, is designed to protect polished and finished surfaces against scratches and die marks during and after fabrication, shipment and storage for periods up to 6 mo in outdoor exposure. According to the company, it will adhere to such materials as stainless steel, aluminum (not anodized), glass, most plated metals, plastic glass, polystyrene and polyester. Although the paper backing is said to resist abrasion, occasional fractures in the backing do not harm the rubbery adhesive which continues to protect the covered surface, according to the company. The No. 344 tape is available in 100-yd rolls in standard widths of 12, 24 and 36 in. Other widths are available on special order.

Ideas Wanted

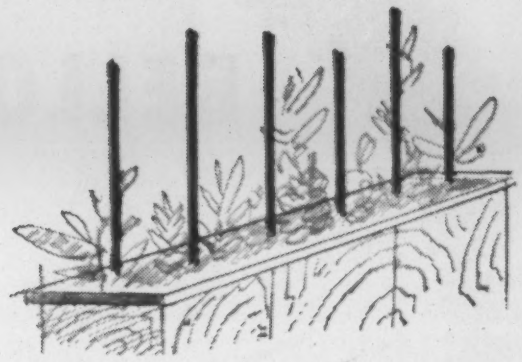
The Scotch brand flock tape at present has unknown industrial applications. Among possible applications are as bottoms or bumpers on table lamps, radios, ash trays, clocks, jewelry boxes, silverware boxes and similar articles. It might also be used in the newspaper or printing industry as a replacement for felt back-up strips before casting rotary

For more information, Circle No. 427

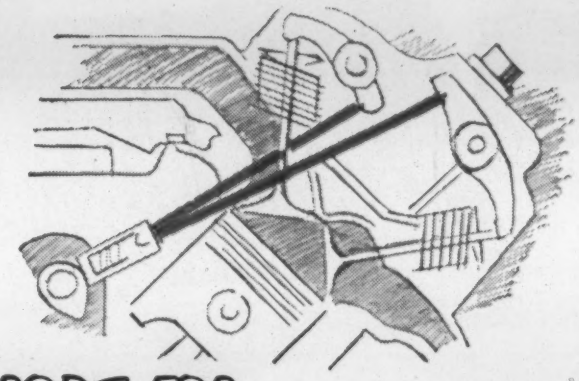
FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



PARTS FOR CHILD'S STROLLER



MODERN ROOM DIVIDERS

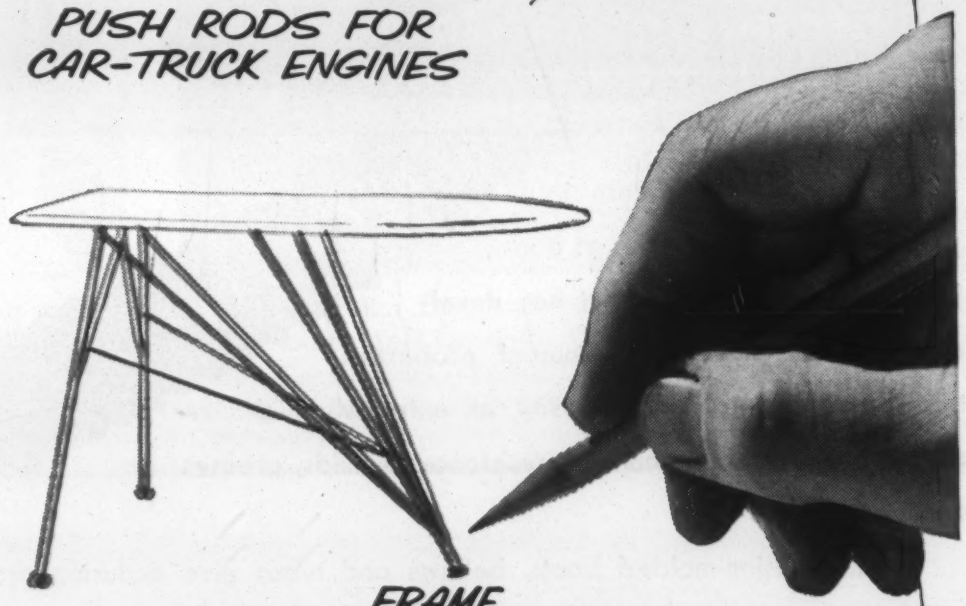


PUSH RODS FOR CAR-TRUCK ENGINES

REMARKS The success (or failure) of that new tubing application hinges largely on the tubing you specify. Why not tip the scales in your favor by using strong, lightweight Bundyweld, the only tubing double-walled from a single metal strip. Added bonuses: Bundy's expert engineering assistance, unexcelled fabrication facilities.

WRITE today for catalog or for help in developing your tubing idea.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN



FRAME FOR IRONING BOARD

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof	Lightweight
High thermal conductivity	Machines easily
High bursting point	Takes plastic coating
High endurance limit	Takes plating
Extra-strong	Bright and clean
Shock-resistant	No inside bead
Ductile	Uniform I.D., O.D.

Bundy Tubing Distributors and Representatives: *Bridgeport, Conn.:* Korhumel Steel & Aluminum Co., 117 E. Washington St. • *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South • *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St., E.
Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

For more information, turn to Reader Service Card, Circle No. 302

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BOOTS

BELLOWS

TUBES

With years of experience in producing great quantities of boots, bellows and tubes, Acushnet has developed rubber stocks with unusual properties that provide sustained flexibility at extremely high or low temperatures, and high resistance to fluids, greases and gases.

Our precision-molded boots, bellows and tubes give enduring protection to moving parts by excluding dust, dirt, water, oil, etc. — or by retaining grease, oil, fuel — or by performing both functions at the same time over long periods of continuous flexing. These products are made on order to customer specifications — none are stocked.

Acushnet
PROCESS COMPANY

Send for your copy of the "Acushnet Rubber Handbook", a comprehensive rubber data source widely used in industry as a reference for molded rubber parts.

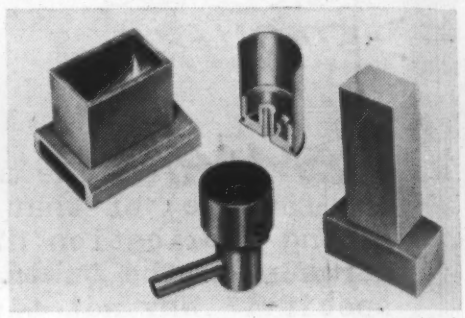
Address all communications to 750 Belleville Ave., New Bedford, Mass.

For more information, turn to Reader Service Card, Circle No. 441

New Materials, Parts and Finishes

press mats, as a lining material inside jewel boxes, purses, vanity and suit cases and silverware boxes, or as decorative trim on such items as lamps, bookends, picture frames and greeting cards.

The 16-mil thick tape is currently available in only ½-in. by 3-yd sample rolls. It could be made in ½- to 26-in. widths on 36-yd rolls in 18 possible colors.



High, Medium and Low Temperature Materials Bonds Aluminum

Three new joining materials, one for use at 375 to 475 F, one for use at 500 to 825 F, and one for bonding at 850 to 1050 F, have been developed for joining all aluminum alloys, both cast and wrought. The materials are said to be anodic with the surface oxide of the aluminum, eliminating the need for special cleaning. Marketed by the *Precision Electronic Research Co.*, Glendora, Calif. and its Canadian branch at 3603 20th St. S.W., Calgary, Alberta, the materials are known as the Percoloy line.

Solbond, designed for the 375 to 475 F temperature range, may be applied with a soldering iron and requires no flux. According to the company it can be used with 2024-T (24S-T), 5052-T (52S-T), 7075-T (75S-T), 1100 (2S), 3003 (3S), etc., without interfering with the heat-treated condition of the material.

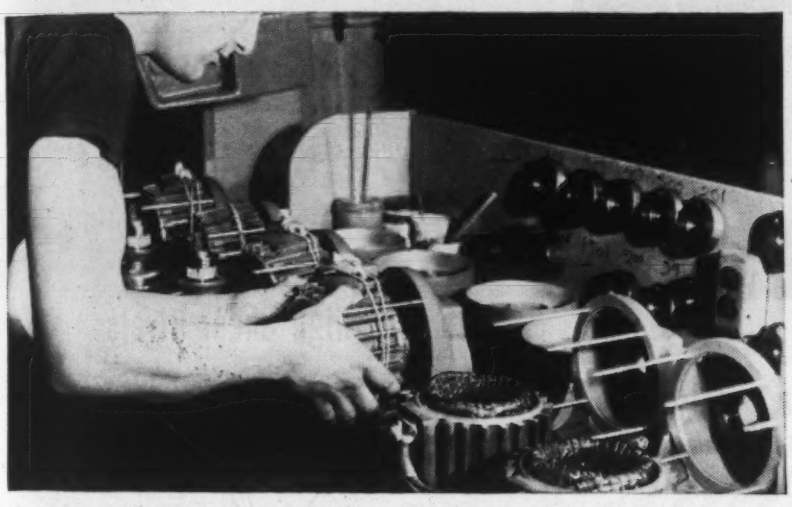
Brabond, designed for the 500 F to 825 F range, is of greater strength, and may be used on all aluminum alloys as well as for all

How MICO® Insulation helps U. S. MOTORS for AIRCRAFT*

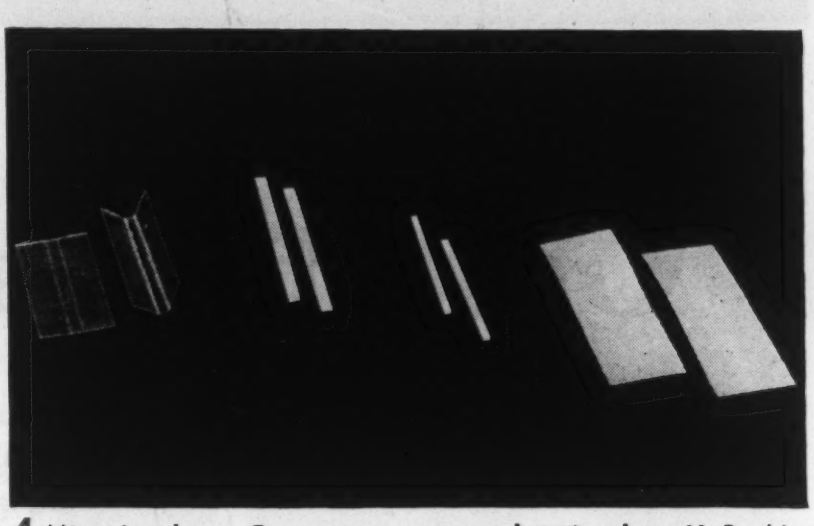
exceed tough specifications for high-temperature performance

1: Cell wall made of ISOMICA® Flexible Plate being inserted into stator slot. Before insertion, the cell wall is cut to size and given a double crease to facilitate assembly.

2. Wound stator shown being subjected to surge test at 1000 V. Any weak spots, cross phasing, unbalanced winding or wrong connections can be detected by oscilloscope pattern.



3. After winding, surge testing and treating, wound stator is assembled into motor. Units pictured are of the totally-enclosed, explosion-proof type with integral gearing, used for powering pumps, compressors, actuators, hoists.



4. Mica Insulator Company parts used to insulate U. S. Aircraft Motors. Left to right: Cell Wall—ISOMICA Flexible Plate; Center Stick—LAMICOID® thermosetting plastic-silicone-glass laminate; Top Stick—LAMICOID; Phase Insulation—ISOMICA.

One of the big problems in aircraft motor insulation is altitude. Lowered air pressure reduces effective cooling by convection and radiation, creates higher operating temperatures. That's why U. S. Aircraft Motors use ISOMICA—a Class H silicone-bonded processed mica with silicone-treated glass cloth on both sides—for phase insulation and cell walls... and silicone-glass LAMICOID—a Class H laminate—for center and top sticks. These superior insulating materials enable U. S. Aircraft Motors to withstand higher temperatures while still retaining minimum weight per horsepower.

We'll be glad to work with you on *your* electrical insulation problems. Whatever electrical insulation material you need—Class A to Class H—MICO makes it best. We manufacture it, cut it to size, or fabricate it to your specification. Write today.

*Product of U. S. Electrical Motors Inc.

MICA *Insulator* COMPANY

Schenectady 1, New York

Offices in Principal Cities

In Canada—Micanite Canada, Ltd., Granby, Quebec

LAMICOID® (Laminated Plastic) • MICANITE® (Built-up Mica) • EMPIRE® (Varnished Fabrics and Paper) • FABRICATED MICA • ISOMICA®

For more information, turn to Reader Service Card, Circle No. 324

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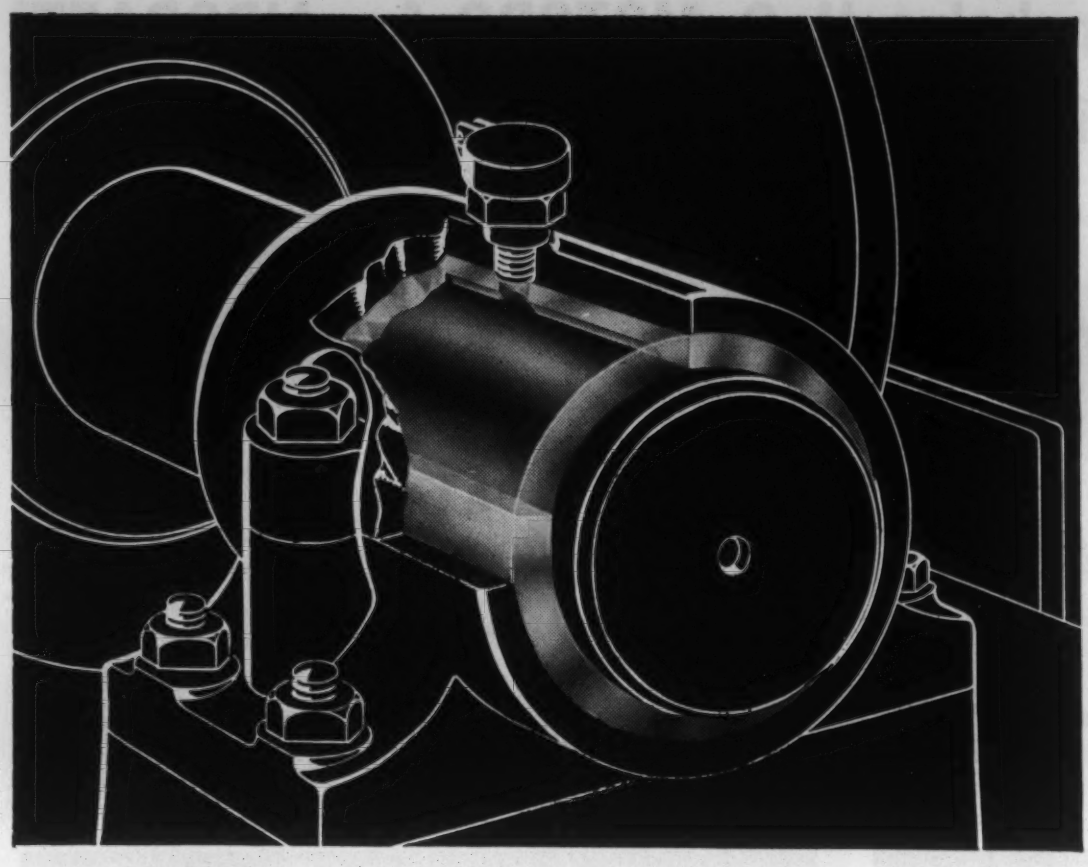


THE WAY TO CUT...

Cost of imitation

If you are using an expensive type of bearing because a competitor of yours uses it you are needlessly saddling expense onto your product if the job could be done as well or better with a less expensive type—as for example the cast bronze sleeve bearing.

Your customer buys your product because it does a job he needs done in the way he wants it done. Your company's name and reputation support your product, and the mere fact that you include unnecessarily expensive bearing types is not a factor in the sale. We suggest you examine your present designs to determine if there are not places where the sturdy, simple, cast bronze sleeve bearing can help you toward necessary cost reductions.

There is a Bunting Engineer near you.
Consult him. Or write our
Product Engineering Department in Toledo.

Bunting®

BRONZE BEARINGS • BUSHINGS • PRECISION BRONZE BARS

The Bunting Brass & Bronze Company • Toledo 1, Ohio

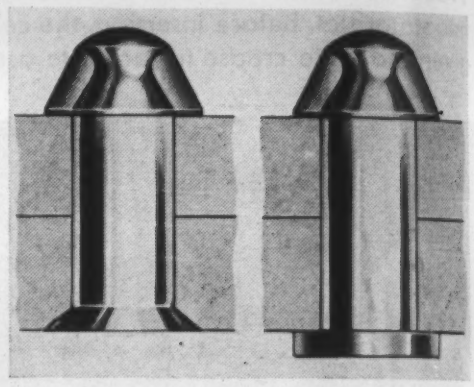
Branches in Principal Cities • Distributors Everywhere

For more information, turn to Reader Service Card, Circle No. 409

New Materials, Parts and Finishes

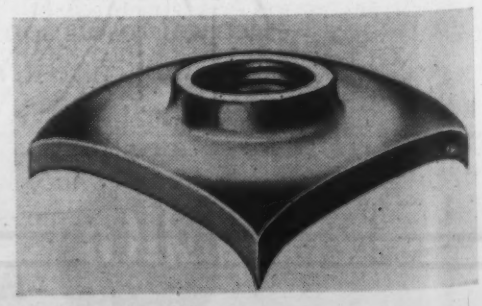
bond combinations between cast and wrought alloys.

Welbond is the highest strength and temperature bonding material. According to the company, bonds may be made at the solution heat-treating temperature, allowing simultaneous bonding and heat treating.



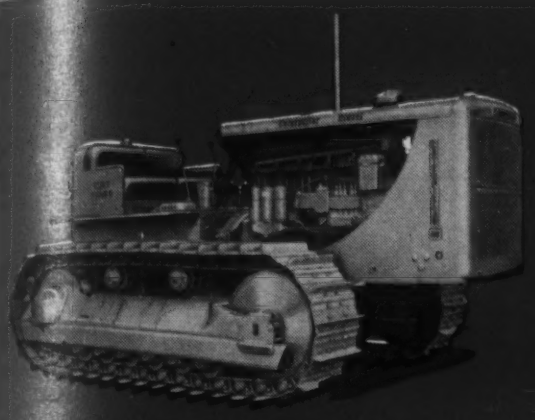
Titanium High Shear Rivets

Made from C-130 titanium alloy, hi-shear rivets offer a 40% weight saving over alloy steel and possess a minimum shear strength of 95,000 psi. They retain useful strengths at elevated temperatures and are corrosion resistant in marine atmospheres and chemical environments. Developed by *North American Aviation, Inc.*, and marketed by their licensee, the *Pheoll Mfg. Co.*, 5720 W. Roosevelt Rd., Chicago 50, the rivets are available in the same types and sizes as alloy steel Hi-Shears being furnished to HS, NAS or customer specifications.



Self-Locking Spring Nut Needs No Washer

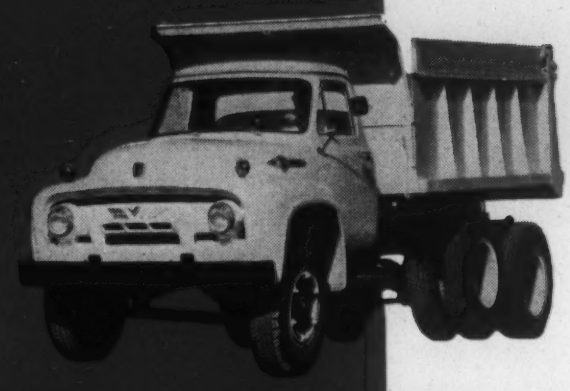
A low-cost nut which speeds assembly and eliminates the need for lock washers has been developed by



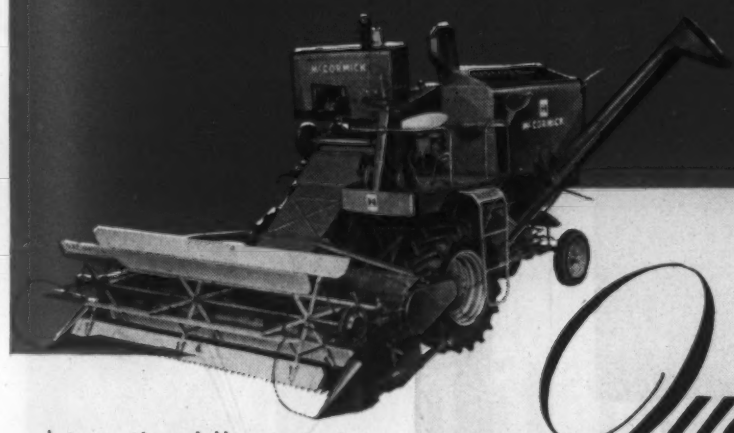
The New 150 H. P. Cat D8 Tractor. Made by Caterpillar Co., Peoria, Illinois.

Newest thing on wings, the new Douglas DC-7, America's fastest and most luxurious airliner starts service.

1954 Chrysler New Yorker Deluxe 4 door, 235 H.P. engine, power steering, power brakes and PowerFlite automatic transmission.



Ford T-800 Tandem Axle Big Job with 170-Horsepower V-8 engine.



International Harvester's New McCormick 141 Self-Propelled Harvester-Thresher

Quality FELT

HELPS PROTECT PERFORMANCE

Modern automotive equipment—airplanes, cars, trucks, tractors, Diesel and marine engines, motorcycles—use felt to protect many vital parts. This versatile and essential industrial material serves to seal out dust, dirt, water, seal in lubricants. Many ball bearings have felt seals which enable the bearing to serve reliably for a lifetime with the lubricant originally installed. Other uses of felt include sound and thermal insulation, vibration control, weather stripping, window channels, lubrication wicks . . . American supplies felt in sheets, strips, wicking, and in parts cut precisely to your blueprints, ready to install. There are many types of felt; for maximum satisfaction, consult American for confidential collaboration on designs and specifications for your various applications. Write on your company letterhead for S.A.E. Felt Standards, including samples and specifications.

American Felt Company

TRADE MARK

GENERAL OFFICES: 24 GLENVILLE ROAD, GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal. PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.

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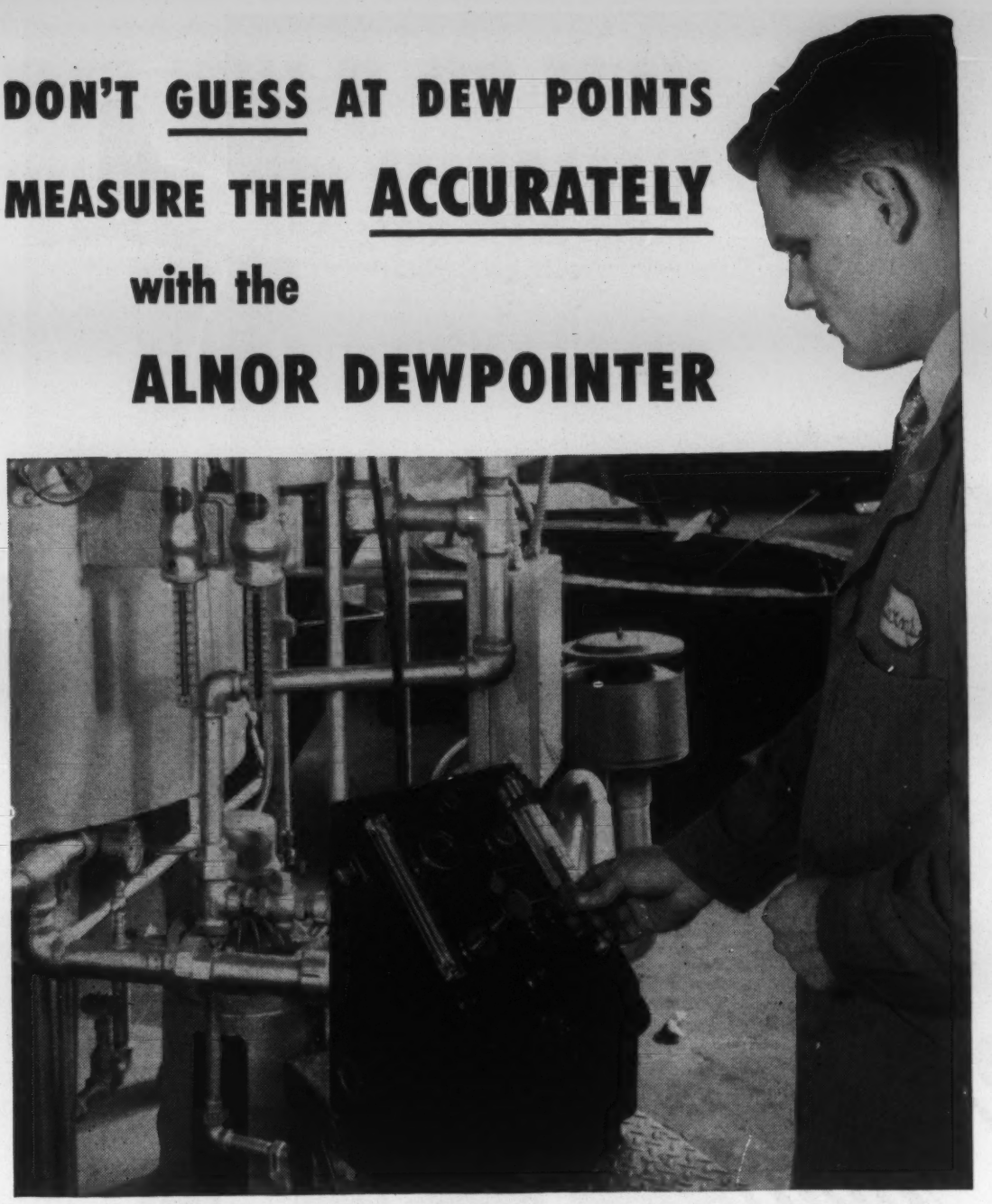
AMERICAN LIBRARIES

DON'T GUESS AT DEW POINTS

MEASURE THEM ACCURATELY

with the

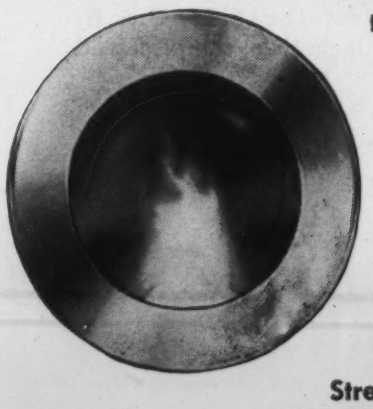
ALNOR DEWPOINTER



Here's the modern way to quickly and *accurately* read the dew point in controlled atmospheres—the Alnor Dewpointer. Its simple, direct operation assures laboratory accuracy by non-technical personnel . . . in the field, plant, or wherever precision checking is necessary for quality results.

The Dewpointer is the only instrument of its kind that is self contained . . . it is readily portable and requires no external coolant or auxiliary apparatus. Operates on either A.C. or enclosed battery power. Over 600 large industrial concerns rely on Dewpointer precision and many find the instrument pays for itself in savings on CO_2 alone.

Guesswork Eliminated



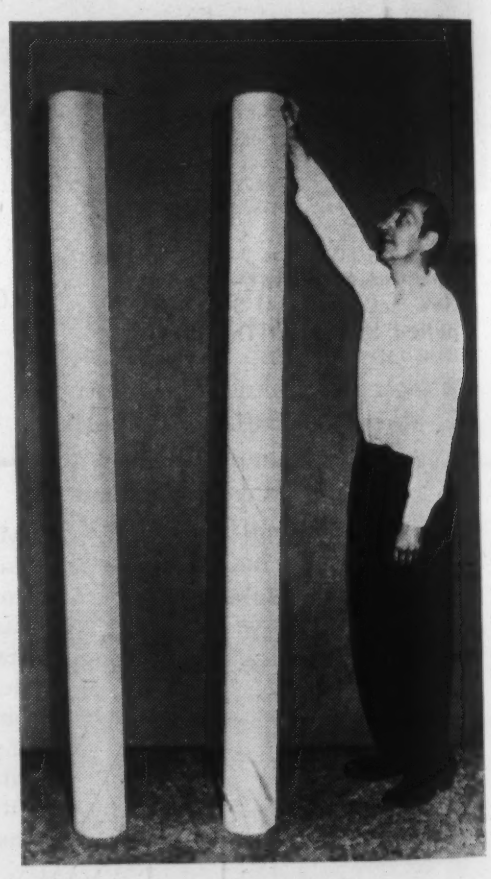
The Dewpointer eliminates all guesswork—as when trying to read indications on a polished surface in other less accurate instruments. You actually see the dew or fog suspended in the enclosed chamber—under conditions that can be controlled and reproduced accurately. You'll want to know more about this unique instrument that brings portable laboratory precision to your dew point determinations, so send today for your copy of the Dewpointer Bulletin. Illinois Testing Laboratories, Inc., Rm. 522, 420 N. La Salle Street, Chicago 10, Ill.

Alnor PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information, turn to Reader Service Card, Circle No. 488

New Materials, Parts and Finishes

the *P-M Nut Div.*, of the *Waterbury Pressed Metal Co.*, 300 Chase Ave., Waterbury, Conn. Made of hardened and spring-tempered high carbon steel, the fastener has a concave shape and turned-down corners which bite into the material as the nut is tightened on the bolt. As the corners dig in, the concave nut is deflected, so that tension is applied to the threads preventing subsequent loosening. Assembly time is said to be reduced since no wrench is needed to hold the bolt as the screw is run into the cut threads. The nut can be removed and reused. Current available sizes are 6-32, 8-32, 10-24 and 10-32, while others are planned.



Jumbo Polyethylene Rods Extruded

The successful extrusion of solid polyethylene rods 6 in. in dia and over 7 ft long, has been achieved by the *H&R Industries*, Nazareth, Pa. The rods are said to be non-porous and free of voids. The company also manufactures polyethylene sheet for punching and cutting purposes as well as rod and tube in a variety of sizes.

(Continued on page 162)

Harden it for 10¢ with TOCCO*

PROGRESSIVE *Kearney & Trecker Corp.*, Milwaukee, Wisc., reports the following savings by TOCCO hardening the above saddle clamp eccentric of their Milwaukee Milling Machine:

	FORMER METHOD	TOCCO
Heat treating	$ 0.721	$ 0.099
Straightening	0.752	0.000
Cleaning	0.100	0.000
Total Cost	$ 1.573	$ 0.099

Saving . . . $1.47 per piece

In addition to this saving of $1.47 per piece, TOCCO made possible a switch from alloy steel to S.A.E. 1045 steel, saving $0.110 in material cost per piece.

Total saving on each run of 1375 pieces for this one part is $2,172.50.

Kearney & Trecker hardens a total of 140 different parts on one "TOCCO JR." machine. Output of some parts has been increased as much as 500%.

Why not enlist TOCCO's experienced Engineers to help you obtain similar improvements for *your* production?

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today

NEW **FREE** BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. T-10, Cleveland 1, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating"

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City_____ Zone____ State_____

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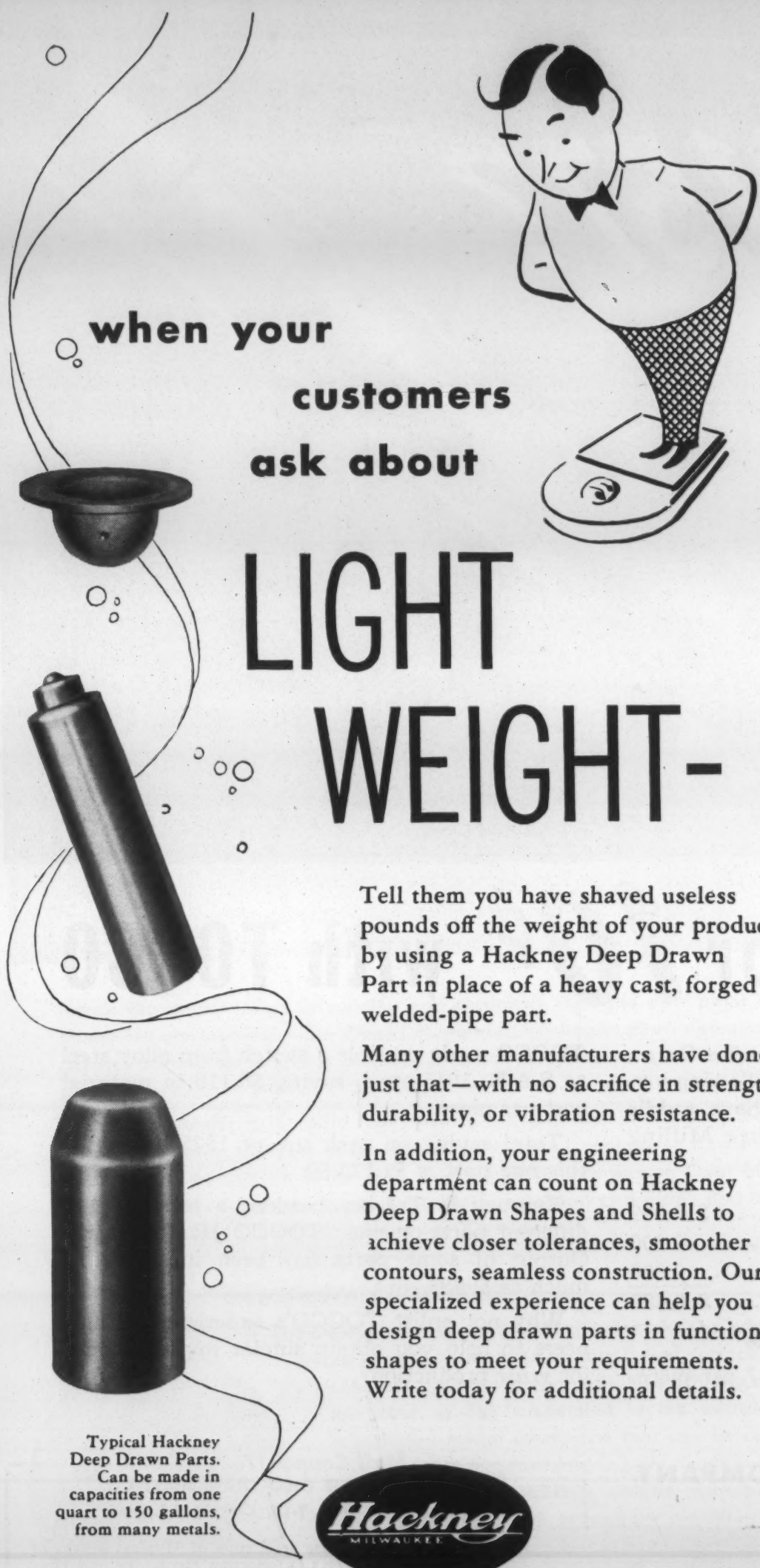

when your customers ask about

LIGHT WEIGHT-

Tell them you have shaved useless pounds off the weight of your product by using a Hackney Deep Drawn Part in place of a heavy cast, forged or welded-pipe part.

Many other manufacturers have done just that—with no sacrifice in strength, durability, or vibration resistance.

In addition, your engineering department can count on Hackney Deep Drawn Shapes and Shells to achieve closer tolerances, smoother contours, seamless construction. Our specialized experience can help you design deep drawn parts in functional shapes to meet your requirements. Write today for additional details.

Typical Hackney Deep Drawn Parts. Can be made in capacities from one quart to 150 gallons, from many metals.

Hackney MILWAUKEE

Pressed Steel Tank Company

Manufacturer of Hackney Products

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241 Hanna Bldg., Cleveland 15 • 936 W. Peachtree St., N.W., Room 111, Atlanta 3
208 S. LaSalle St., Room 788, Chicago 4 • 559 Roosevelt Bldg., Los Angeles 17
18 W. 43rd St., Room 11, Kansas City 11, Mo. • 136 Wallace Ave., Downingtown, Pa.

CONTAINERS FOR GASES, LIQUIDS AND SOLIDS

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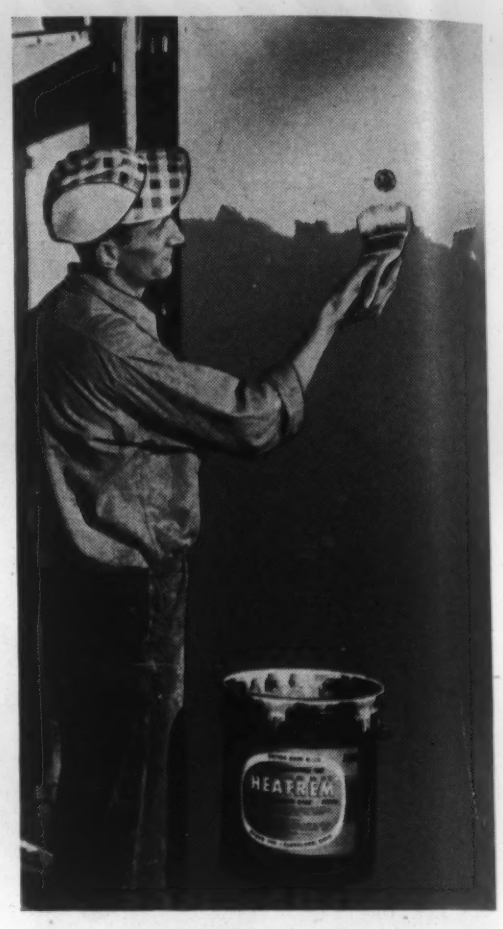
New Materials, Parts and Finishes



Better Adhesion for High Temperature Paint

Improvement of adhesion and appearance of Heat-Rem H-170, heat resistant aluminum paint is claimed by the producer, *Speco, Inc.*, Cleveland, Ohio. According to the manufacturer, this is the result of a new combination of non-leafing and leafing aluminum in the paint compound.

The non-leafing particles of aluminum are said to remain suspended in the paint vehicle and to provide a uniform quantity of aluminum throughout the applied coat. The resulting protective coating is capable of withstanding temperatures of approximately 1700 F, according to the producer. The leafing particles in the paint rise to the surface upon application and are said to form an elastic finish that is resistant to moisture, corrosion, mild acids, alkalis and industrial fumes.

The paint is designed for application such as heat lines, condensors, compressors, ovens, engine heads, mufflers, radiators, and exhaust manifolds. The paint will dry at room temperature, and is available in metallic red, blue and gold.

(Continued on page 164)

OIL RESISTANCE

WEATHER RESISTANCE

FLEXIBILITY

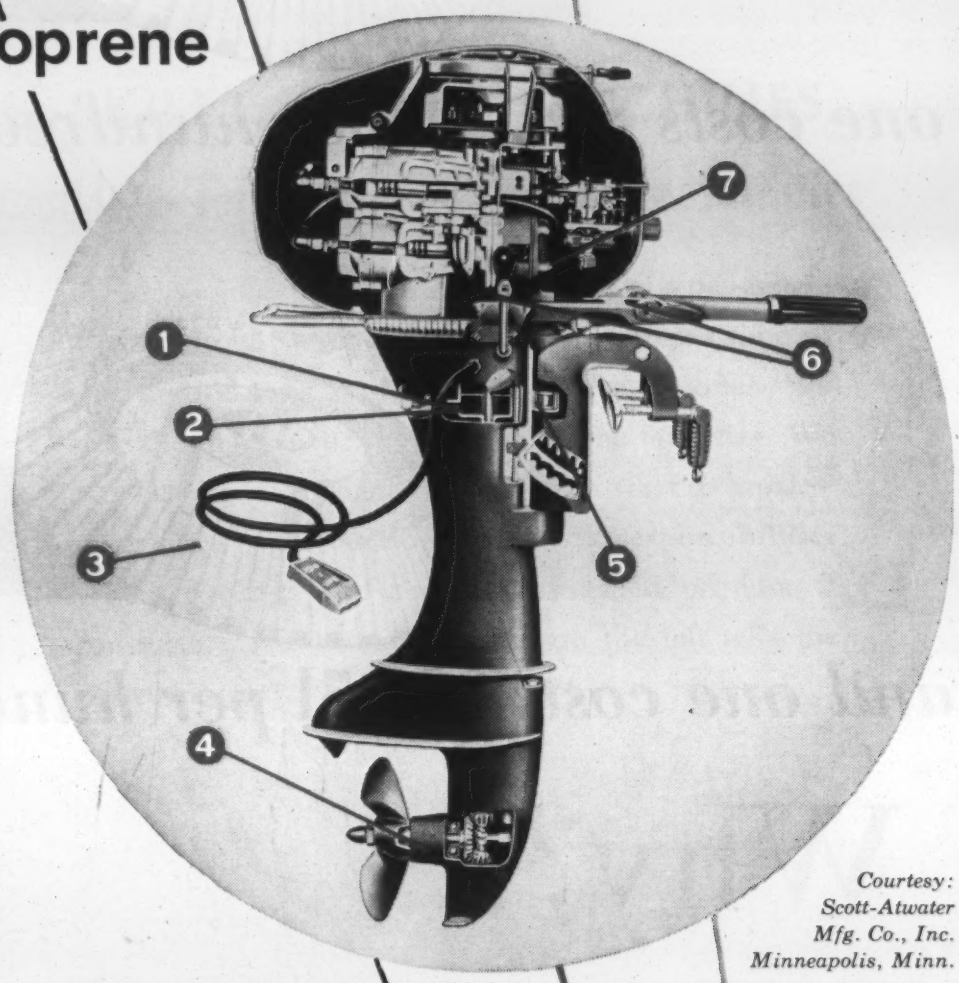
These properties of neoprene make a better OUTBOARD MOTOR

Smart streamlining distinguishes this new '54 outboard—and there's ample evidence of the designers' attention to mechanical detail as well. For no less than 7 parts are made with Du Pont neoprene to improve performance and reduce the need for maintenance.

An outstanding feature of this motor is an automatic bailing device—linked from an immersion unit to the motor by durable neoprene hose which can withstand the effects of seasons of direct sunlight and weathering without cracking. The bailing pump itself makes use of neoprene in a unique rotor which can withstand constant abrasion.

Neoprene is also employed for the carburetor line because gasoline has little effect on it. And in the propeller hub, shock-absorbent neoprene gives lasting protection even in salt water.

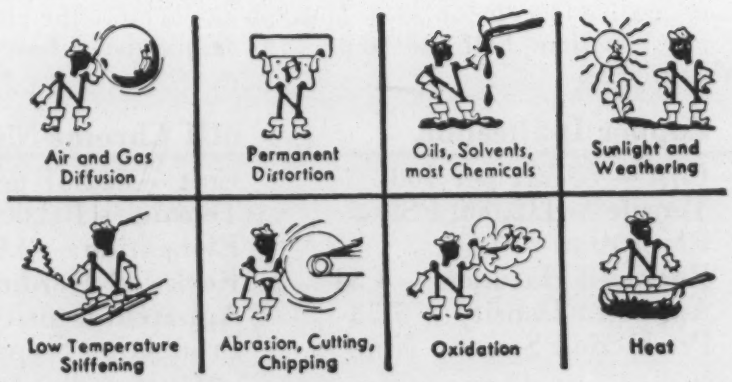
Finally, the entire motor is suspended in a resilient neoprene cushion to reduce noise and vibration. With *all* these features provided by *one* resilient material, it's small wonder that today more designers are turning to neoprene than ever before.



Courtesy: Scott-Atwater Mfg. Co., Inc. Minneapolis, Minn.

1 Bailing pump rotor
2 Cooling pump rotor
3 Bilge Hose
4 Shock-absorbent hub
5 Motor cushion
6 Remote control cables (not shown)
7 Carburetor drain line

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:



NEOPRENE

The rubber made by Du Pont since 1932

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

***FREE!* THE NEOPRENE NOTEBOOK**

Each issue shows new, unusual applications of neoprene . . . new products . . . improved designs. Add your name to the mailing list today.

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division MM-10 Wilmington 98, Del.

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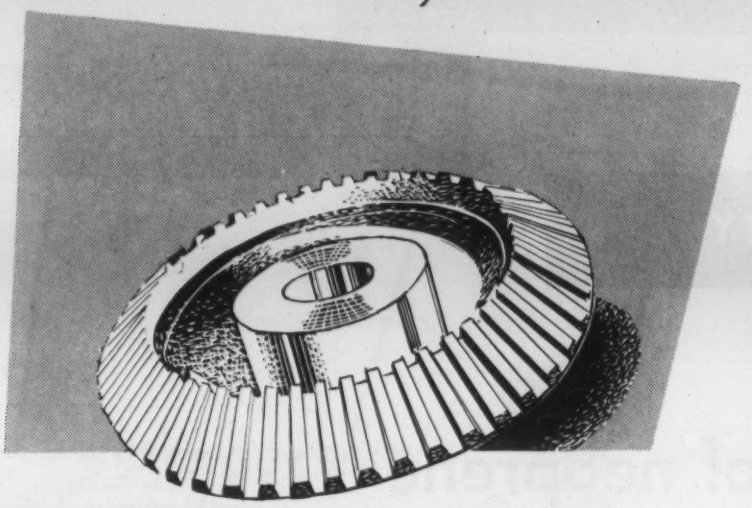
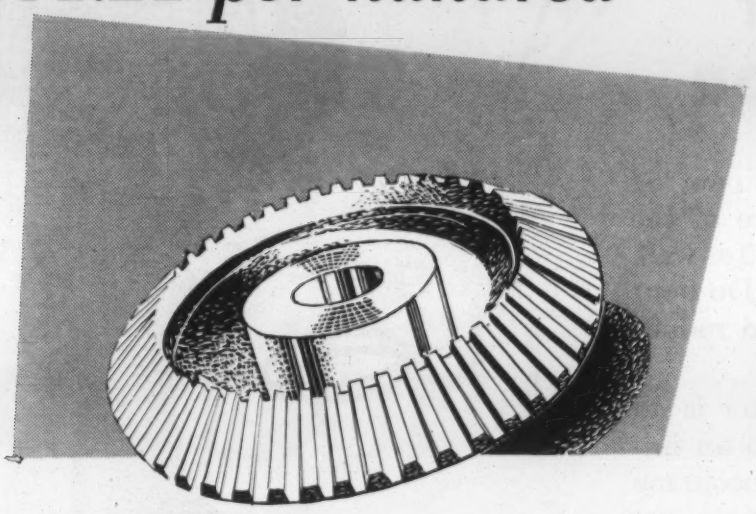
*City*_____ *State*_____

For more information, turn to Reader Service Card, Circle No. 316

With Tensiles Over 100,000 PSI



one costs $31.21 *per hundred*



and one costs $22.51 *per hundred*

Why?

With reduced iron powders in both cases . . . the expensive compact derives its physicals from copper infiltration; the inexpensive compact from small additions of Metal Hydrides' chromium-nickel pre-alloyed powders. The comparative facts below show how you can achieve the physicals you need . . . in less than half the steps . . . at impressively lower cost with the MH process.

Copper Infiltration	**MH Chrome-Nickel***
Cost — $31.21 per 100	**Cost — $22.51 per 100**
Tensile — 112,000 PSI	**Tensile — 103,000 PSI**
Elongation — 1%	**Elongation — 2.5%**
Rockwell Hardness — C34	**Rockwell Hardness — B100**
Apparent Density — 7.78	**Apparent Density — 6.83**
Production Steps — Nine	**Production Steps — Four**

**(7½% addition of 50% chrome/ 50% nickel, plus 1% carbon)*

Without obligation our technical sales staff will gladly give you complete information and show you how chromium-nickel pre-alloyed powders will meet your requirements. Write today!

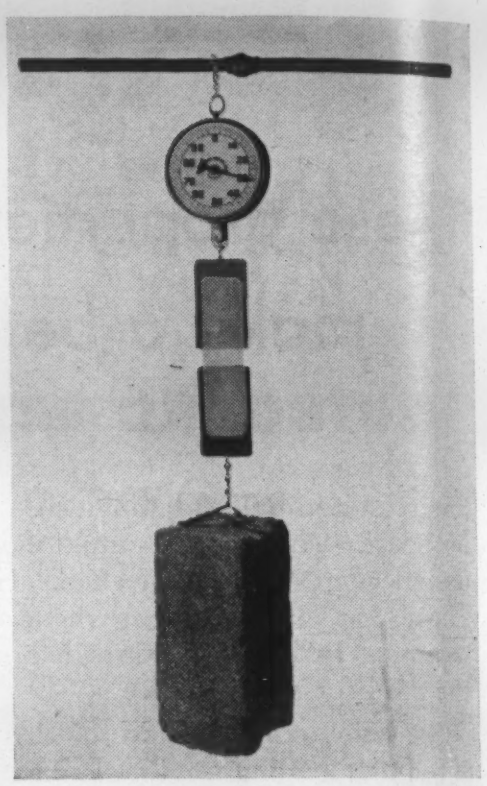
Pioneers In Hydrogen Compounds

M H **Metal Hydrides** INCORPORATED

16 CONGRESS ST., BEVERLY, MASS.

For more information, turn to Reader Service Card, Circle No. 456

New Materials, Parts and Finishes



Adhesive Bonds the Fluorocarbon Plastics

A pressure-sensitive adhesive for bonding Teflon to itself and other materials such as metals, glass, paper or other plastics, has been marketed under the name Flexrock #80 by the *Flexrock Co.,* 36th & Filbert St., Philadelphia 4. The adhesive is said to provide peel strengths with Teflon-to-Teflon bonds of about 2 lbs per in. of width, and shear strengths of 12 to 15 psi. The material maintains its pressure-sensitive characteristics over a temperature range of —65 to 390 F. It is said to have good acid and alkali resistance, but it is affected by most organic solvents and is not recommended for use in such applications.

Typical properties claimed for the material are as follows:

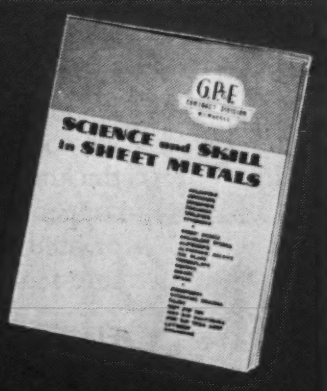
Solids, Content, %	40
Specific Gravity	0.94
Viscosity at 75 F, cps	1000-3000
Dielectric Constant at 10^2 cycles	2.8
Dielectric Strength, v/mil	550-650
Power Factor at 10^2 cycles	0.005
Surface Resistivity, Meg ohms, after 4 days at 100% relative humidity	2000

It can be applied by brush or knife or it may be sprayed or dipped by thinning to suitable viscosity. After the adhesive is applied, it

if you need ... LARGE AND MEDIUM-SIZED SEAMLESS STAMPINGS we offer ... SKILL ... MEN ... MACHINES ...

plus complete finishing and assembly facilities

Send for your free copy of our booklet—"Science and Skill in Sheet Metals." It illustrates many jobs produced for G. P. & F. customers . . . and gives interesting information on our abilities and facilities.

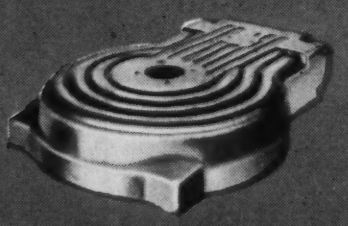


Do you have a metal product—or a part of a product—that has to be stamped or drawn? Then it's time to take a good look at what G. P. & F. has to offer. We have the manpower, the machines, the facilities. We can handle your *complete* job from start to finish—relieve you of production details and responsibilities—even package and ship your finished product, if you wish. The booklet shown on the left tells the complete story. Write for it today!

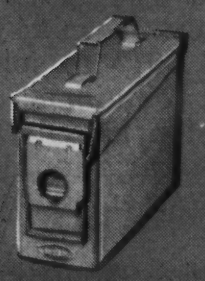
G.P.&F.

Here are just a few samples of our work...

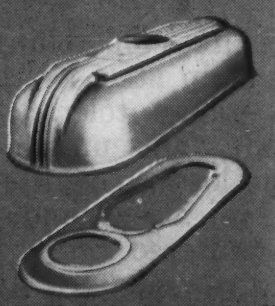
OVERFLOW TUB FOR AUTOMATIC WASHING MACHINE
Welded Construction
Vitreous Enameled
Height, 21"—Diameter, 24"
(Also conventional and spin tubs)



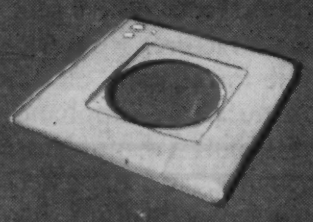
BASE FOR POWER LAWN MOWER
Seamless Drawn Steel
Length, 26"—Width, 19⅛"
Height, 4¾"



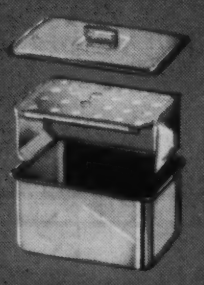
AMMUNITION BOX (U.S. ORDNANCE)
Carbon Steel—Spray Painted
Length, 10"—Height, 7"
Width, 3⅜"



POWER TOOL SAFETY GUARD
Seamless Drawn
Length of Cover, 29¾"
Height of Cover, 5¼"
Width of Cover, 10⅛"

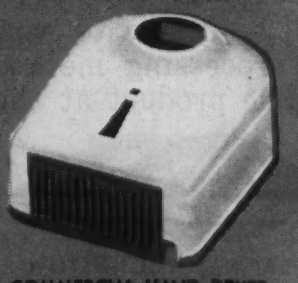


TOP FOR AUTOMATIC WASHING MACHINE
Stainless Steel and Vitreous Enameled
Length, 26"—Width, 25"
Height, 2½"
(Also dryer tops)



SYRINGE HOLDER
Stainless Steel Box, Cover and Rack
Length, 8¼"
Height and Width, 5"

BASE FOR SWIVEL CHAIR
Seamless Drawn Carbon Steel
Length, 25"—Height, 4"



COMMERCIAL HAND DRYER
Seamless Drawn—Vitreous Enameled
Length, 12"—Width, 10½"
Height, 6⅛"

GEUDER, PAESCHKE & FREY CO., 1538 W. St. Paul Avenue, Milwaukee 1, Wisconsin

For more information, turn to Reader Service Card, Circle No. 314

CMP COLD ROLLED STRIP STEEL

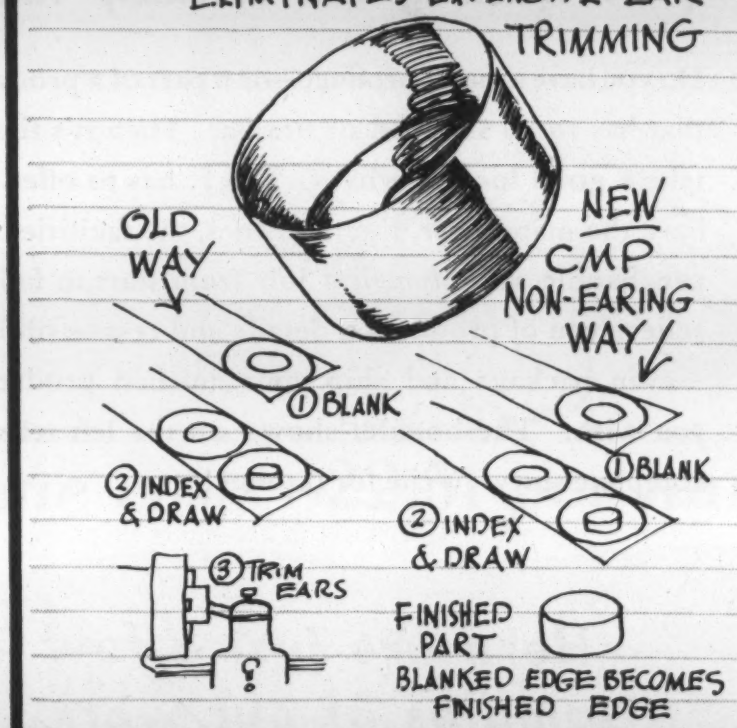
OFFERS *a practical way*

to reduce end-product costs

WITHOUT CAPITAL INVESTMENT

Typical Case

Specially processed for the requirement, CMP provides a non-earing strip steel for deep drawn parts and ELIMINATES EXPENSIVE EAR TRIMMING



CMP's precision rolling process permits production of cold rolled strip steel as thin as .001″ to split-hair across-the-width gauge tolerances not obtainable by other rolling methods. This unique precision is reflected in less square footage loss through oversize variation, less wear on tools, fewer rejections and faster assembly where close fitting is encountered.

CMP processes also permit close control of physical characteristics to develop the combination of physicals best suited to the fabricating and service requirements of the application.

We'll be happy to work with you to develop specifications and processing methods to enable you to make the best possible product at the lowest possible cost.

the Cold Metal Products co.

GENERAL OFFICES: YOUNGSTOWN 1, OHIO

PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, INDIANA

SALES OFFICES: New York • Cleveland • Detroit • Indianapolis • Chicago • St. Louis • Los Angeles • San Francisco

LOW CARBON, HIGH CARBON (Annealed or Tempered), STAINLESS AND ALLOY GRADES, ELECTRO ZINC COATED ARE AVAILABLE FROM:

THE COLD METAL PRODUCTS CO. OF CALIFORNIA
6600 McKinley Avenue, Los Angeles Phone: PLeasant 3-1291

THE KENILWORTH STEEL CO., 750 Boulevard, Kenilworth, New Jersey
Phones: N. Y., COrtlandt 7-2427; N. J., UNionville 2-6900

PRECISION STEEL WAREHOUSE, INC.
4425 W. Kinzie, Chicago Phone: COlumbus 1-2700

For more information, turn to Reaedr Service Card, Circle No. 306

New Materials, Parts and Finishes

must be dried before joining the surfaces. Air drying for several hours is satisfactory or heating for 15 to 30 min at 160 to 212 F. An additional 5-min cure at 300 F will increase the bond strength.

Three New Tapes: Electrical, Unsupported, Sound Dampening

Three new industrial tapes have been produced by the *Permacel Tape Corp.*, Highway 25, New Brunswick, N. J. One is an electrical pressure-sensitive tape which can be heat cured for greater adhesion; another is an unsupported adhesive film which provides a uniform adhesive thickness between such materials as copper and phenolic board for printed circuits; the third is a pressure-sensitive sound-damping tape.

Electrical Tape

P 21 Glass Cloth Electrical Tape H.C. incorporates a 60 x 52 glass cloth backing and a crude-synthetic adhesive mass with a heat-curing resin. In its uncured state it is said to possess good pressure-sensitive adhesive qualities. It can also be subjected to a cure of 2 hr at 250 F or 1 hr at 300 F to provide a firm, solvent-resistant adhesive bond.

Although strong under straight tension the glass thread will fracture under whipping or snapping. The backing is fire-resistant, but the adhesive mass is susceptible to flame. The tape meets Class B Electrical Insulation requirements and is said to provide high abrasion resistance; however, once cured, if subjected to high temperatures, further chemical changes occur tending to uncure the adhesive mass.

The tape is expected to find application in electric motor and generator manufacture, electric transmission line installation, electronic equipment manufacture, appliance manufacture, transport manufacture and maintenance, and in general industry for bake oven sealing, hot air duct sealing and splicing of heavy sheeting for processing.

Properties of the tape are as follows:

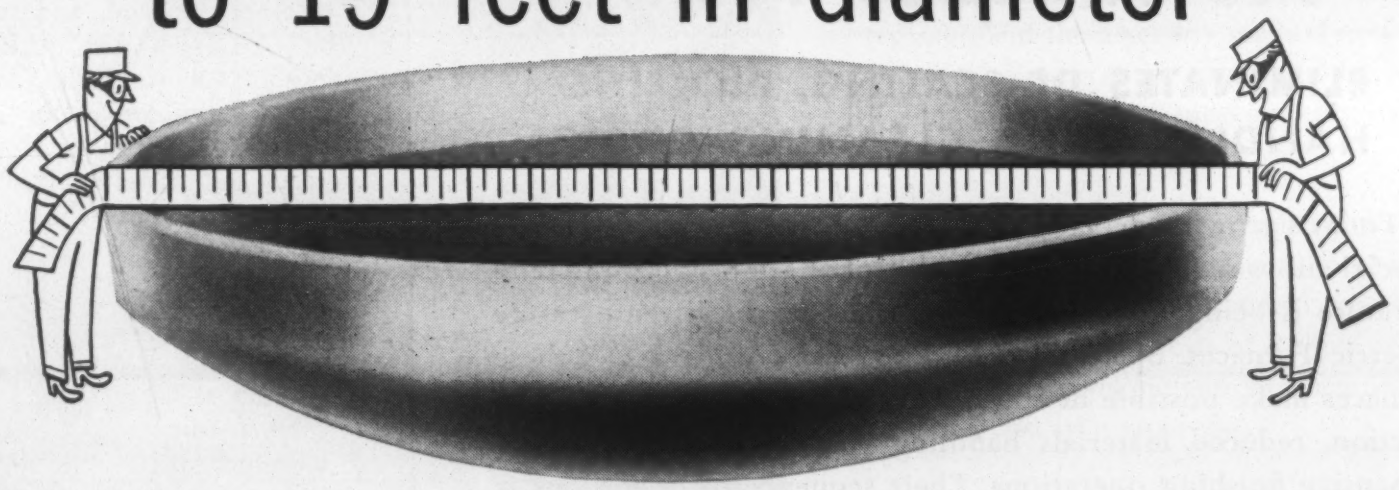
Tensile, psi	150
Adhesion, oz/in. of width	30

(Continued on page 168)

CLAYMONT FLANGED AND DISHED HEADS

from 9 inches

to 19 feet in diameter



Flanged and dished heads made by Claymont are available in sizes from as small as 9 inches to as large as 19 feet in overall diameter; and in gauges from 3/16-inch to 6 inches. They can be supplied in carbon steel, alloy steel or with stainless steel cladding.

All carbon and alloy steels are the product of our own open hearth furnaces—closely and completely controlled to meet customers' specifications.

We are also prepared to handle head-forming operations on both ferrous and non-ferrous metal supplied by the customer. To order, write or call Claymont Steel Products Department, Wickwire Spencer Steel Division, 813 West Street, Wilmington 99, Delaware.

Claymont Steel Products

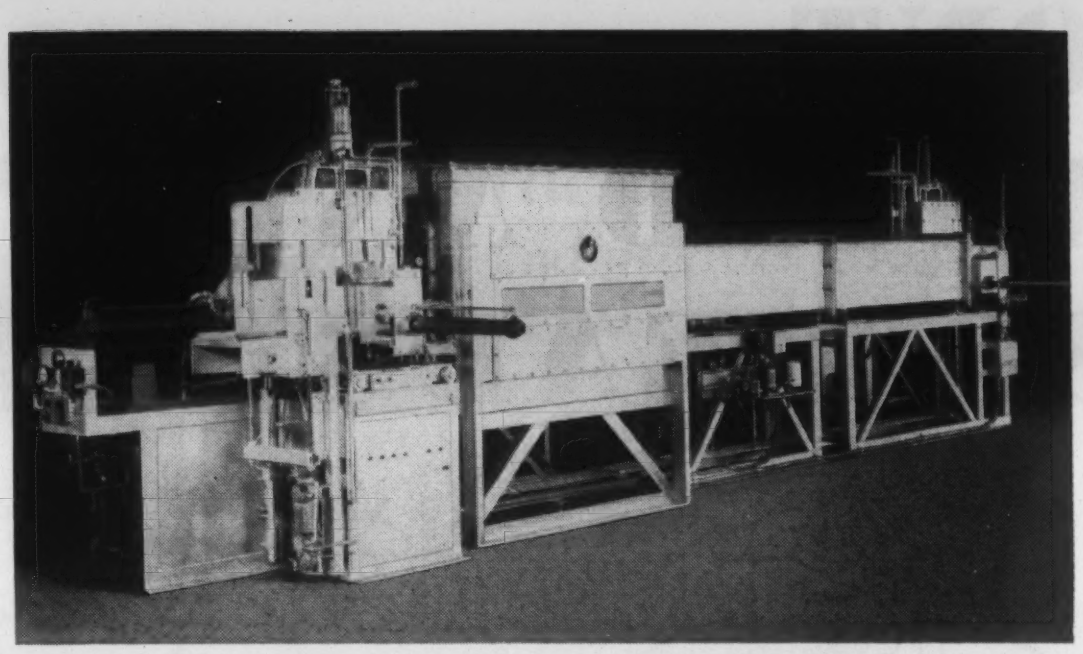
Products of Wickwire Spencer Steel Division • The Colorado Fuel and Iron Corporation

2576

Abilene • Albuquerque • Amarillo • Atlanta • Boise • Boston • Buffalo • Butte • Casper • Chicago • Denver • Detroit • El Paso • Ft. Worth • Houston • Lincoln (Neb.) • Los Angeles
New Orleans • New York • Oakland • Odessa • Oklahoma City • Philadelphia • Phoenix • Portland • Pueblo • Salt Lake City • San Francisco • Seattle • Spokane • Tulsa • Wichita
CANADIAN REPRESENTATIVES AT • Edmonton • Toronto • Vancouver • Winnipeg

Other *Claymont Products* . . . Carbon and Alloy Steel Plates • Stainless-Clad Plates • Manhole Fittings and Covers • Large Diameter Welded Steel Pipe • Flame Cut Steel Plate Shapes

* For more information, turn to Reader Service Card, Circle No. 480



Harper Automatic Pusher Type Furnace for bright brazing stainless steel using copper or stainless brazing compound in dry hydrogen atmosphere.

BRIGHT BRAZING *and* ANNEALING *"the Harper Way"*

ELIMINATES DE-SCALING, PICKLING HANDLING AND CLEANING COSTS

● Today's growing demands for automatic processing of the new special alloys requiring precision control of atmosphere and temperature is being met by Harper-engineered high temperature Electric Furnaces. Specially designed *"The Harper Way"* these furnaces make possible new economies through integrated production, reduced materials handling costs and elimination of expensive finishing operations. Their sequence of operations is timed and synchronized to protect intricate and costly assemblies when brazing and annealing stainless steel and non-ferrous parts on a continuous basis.

Let us show you how *The Harper Way* of heat processing produces a high quality product with new economy.

See the Harper Furnace Exhibit at the Metal Show in Chicago Booth 1919

Furnace Builders for over 30 Years

HARPER
Electric Furnace Corp.
38 RIVER ST., BUFFALO 2, N. Y.

Representatives in Principal Cities

For more information, turn to Reader Service Card, Circle No. 491

New Materials, Parts and Finishes

Elong., %	5
Thickness, mil	7
Insulation Resistance, 96% megohms	2000
Dielectric Strength, v	1800
Electrolytic Corrosion Factor	0.95
Chlorides, %	0.02

Unsupported Adhesive Film

Permacel 18 Adhesive Film (2 mil) is a green industrial laminating adhesive supplied in dry film form with paper interliner. The tape provides a smooth, continuous film of controlled thickness at the glue line. Since it is in dry form, application is simplified and the absence of solvents provides safe operating conditions. Storage problems are said to be simplified and the tape can be die cut or preformed with interliner still in place. During application a uniform heat and laminating pressure are required, and surfaces must be free from rust, scale, grease or loosely adhering film. Primary uses for the film are in the manufacture of printed circuits and in the electrical and metal-working industries.

Properties of the film are as follows:

Thickness, in.	0.002
Color	Green
Optimum Application Conditions:	
Temp at Glue Line, F	325-350
Time, min	10-20
Presure, psi	100-2000
Heat Resistance after Cure:	
Copper to 3 XP Phenolic Panel, lb/in. width	8
Heat Resistance after Cure:	
Solder Dip Test (410 F for 10 sec)	Excellent
Resistance to Water after Cure	Excellent
Resistance to Solvents after Cure:	
Ketones and Esters	Fair
Alcohols, Aliphatic and Aromatic Hydrocarbons	Excellent

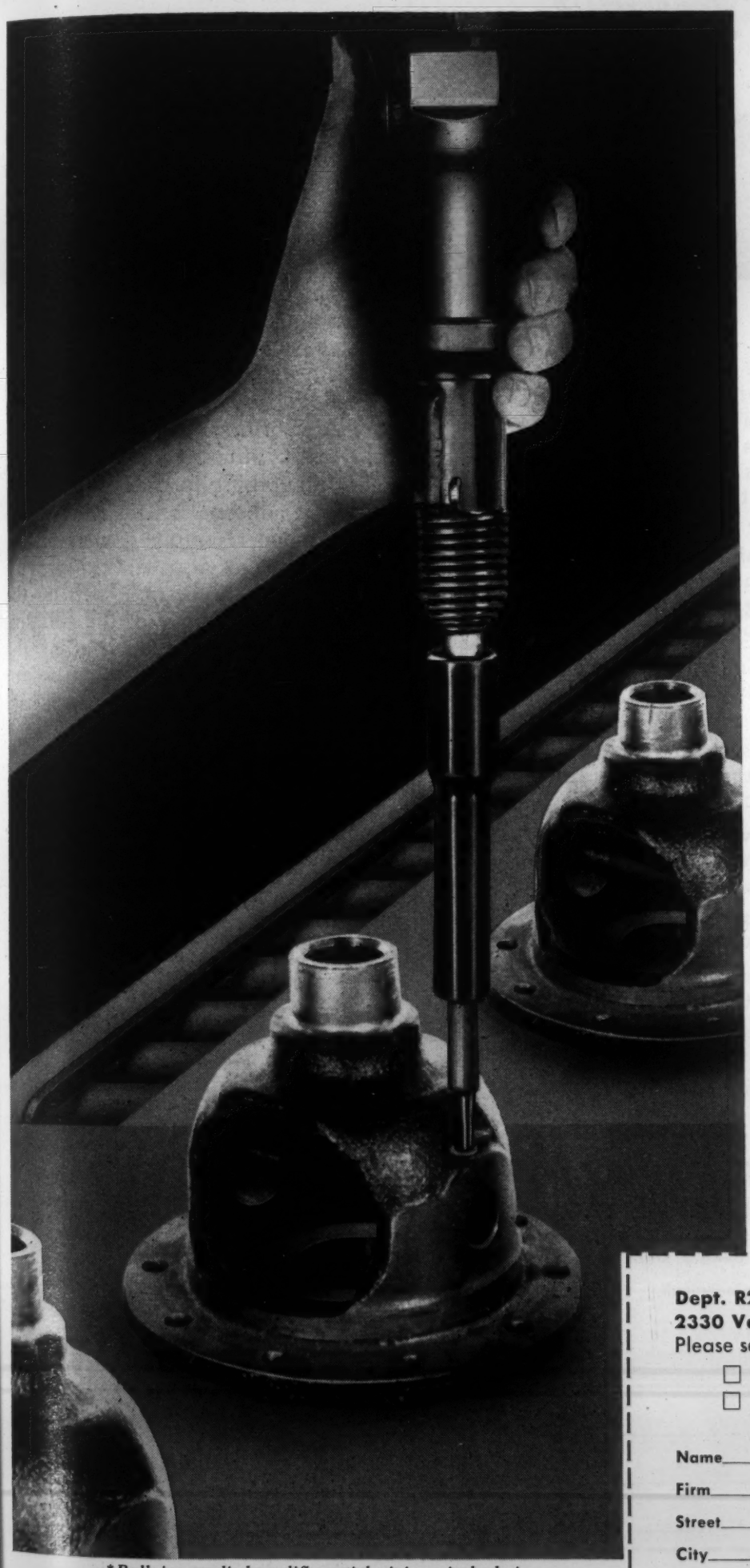
Typical shear values for laminations of various materials are as follows:

Materials Bonded	*Shear, psi*
Cold rolled steel	5100
Brass	5150
Galvanized iron	3050*
Aluminum	4700
Phosphor bronze	4650

(Continued on page 170)

Ford Cuts Assembly Costs using

ROLLPIN
TRADE MARK



Rollpins applied as differential pinion pin lockpin on the Ford Motor Mound Road Plant assembly line.

Rollpin is the slotted tubular steel spring pin with chamfered ends. Simply drive it into holes drilled to normal production tolerances. It compresses as driven—and its spring action locks it in place regardless of impact loading, stress reversals or vibration.

Rollpin assembly eliminates extra operations and parts. There is no precision drilling, threading, peening—and no cotter pins or other locking devices. Cost savings as great as 90% result—depending upon the type of fastener replaced and the assembly method now in use. Our illustration is an air gun set-up that installs Rollpin at the rate of 8 units a minute on the Ford assembly line.*

Other insertion procedures range from simply driving Rollpin with a hammer to more intricate hopper-fed methods. Independent time studies have shown installed costs of Rollpin at *9%* of that for a dowel pin and *less than 5%* of the installed cost of a taper pin.

Mail our coupon for information on how Rollpin will do your fastening faster and cheaper.

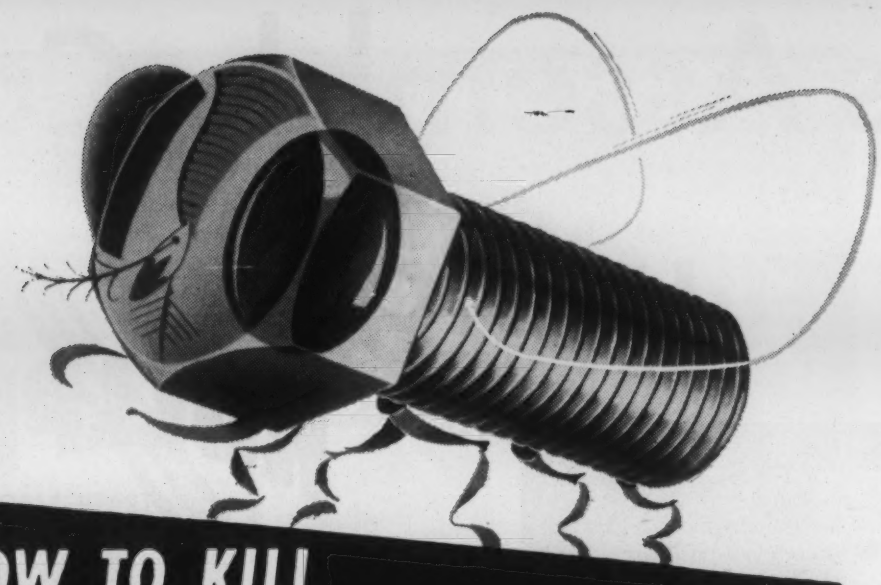
ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. R23-1061, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey
Please send the following free fastening information:

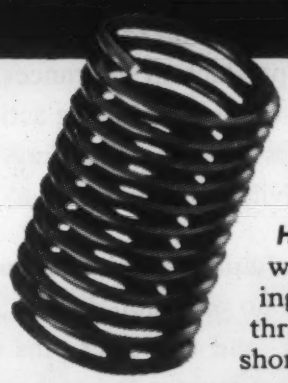
☐ Rollpin bulletin ☐ ELASTIC STOP® nut bulletin
☐ Here is a drawing of our product.
What ESNA® fastener would you suggest?

Name_____ Title_____
Firm_____
Street_____
City_____ Zone____ State_____

For mor einformation, turn to Reader Service Card, Circle No. 389



HOW TO KILL 5 thread fastening bugs in design...



Been Stung BY TOO MUCH WEIGHT? ***Heli-Coil**** Inserts permit weight reduction two ways: They require less space than solid bushings. Need no greater boss radius than unprotected thread assemblies. Permit the use of fewer, smaller, shorter threaded fasteners.

Been Stung BY WEAK THREADS? ***Heli-Coil*** Inserts provide a minimum of 25% greater loading strength than unprotected threads in the same material. You eliminate stripping, even in soft materials such as aluminum, magnesium, plastics, wood, etc.

Been Stung BY THREAD WEAR? ***Heli-Coil*** Inserts can't wear — therefore no customer complaints about worn threads; field service costs are cut.

Been Stung BY CORROSION? ***Heli-Coil*** Inserts are corrosion-proof stainless steel or phosphor bronze. They withstand temperatures up to 800°F. indefinitely — won't seize, gall or corrode.

Been Stung BY VIBRATION? Vibration will not loosen ***Heli-Coil*** Inserts; will not damage insert-protected threads. Fits are inherently better; stresses are more evenly distributed.

When you use *Heli-Coil* Screw Thread Inserts you kill *all five* of these design bugs *at once*.

To find out ***why*** the ***Heli-Coil*** Insert method of thread protection is the simplest, most effective, and most practical . . . to get all the data you need to design these advantages into your product . . . to get free samples of ***Heli-Coil*** Inserts, use this handy coupon.

*Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
190 SHELTER ROCK LANE, DANBURY, CONN.

☐ Send samples and Bulletin 689 — Military Standard Sheets.
☐ Please have a *Heli-Coil* Thread Engineer call.
☐ Send samples and Catalog.

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 2654

***Heli-Coil* Inserts conform to official military standards MS-122076 (ASG) through MS-124850 (ASG) and others.**

New Materials, Parts and Finishes

Chromium steel	4900
Phenolic laminate	1050*

* Panel failed without affecting cement bond.

Sound Damping Tape

P 12 Acoustimat Sound Damping Tape is a combination of aluminum foil, 68 x 72 unbleached cotton cloth and a rubber-base, pressure-sensitive adhesive. This is said to provide effective sound damping characteristics where sound is transmitted through metal panels. The aluminum foil is separated from the metal panel to which it is attached, by 14 mils of adhesive and cloth, providing a truss effect which adds to the stiffness of the panel. The increased stiffness combined with the shock absorbing qualities of the rubber-base adhesive is said to result in high sound damping characteristics.

The tape is also said to provide good thermal insulation both by the low heat conductivity of the adhesive and the reflective properties of the foil. It requires only a roller for application, and when applied is said to be flame proof.

The tape is expected to find applications in the aircraft, automotive, metal furniture and heavy transportation industries, and for stainless steel fabricators.

Properties of the tape are as follows:

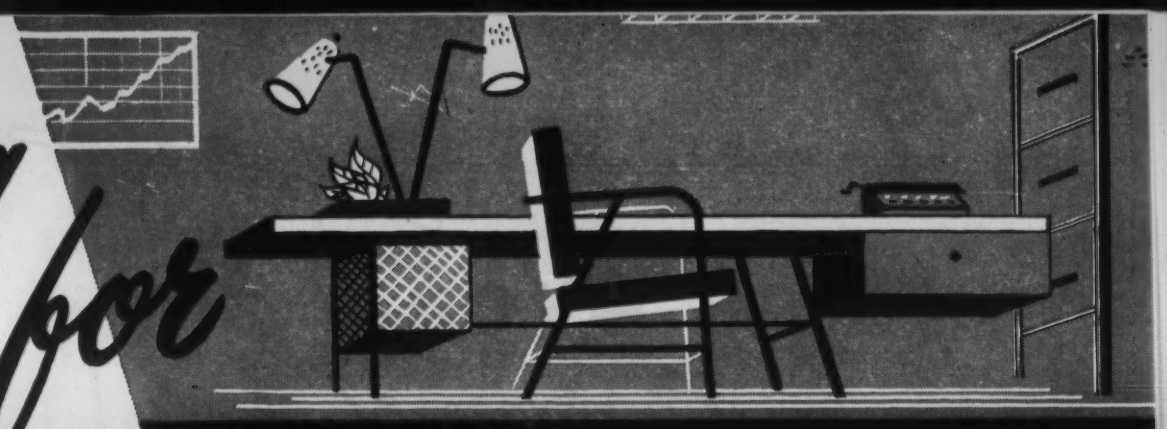
Tensile, lb/in. of width	45
Adhesion, oz/in. of width	35*
Elong., %	10
Thickness, mil	16
Sound Attenuation Factor, (Based on a factor of 1.0 for 1/16-in. mica sheeting)	1.40
Thermal Insulation "k" Factor	0.00427
Moisture Vapor Transmission Rate	0.00

* Due to thickness of backing, standard ASTM method cannot be used.

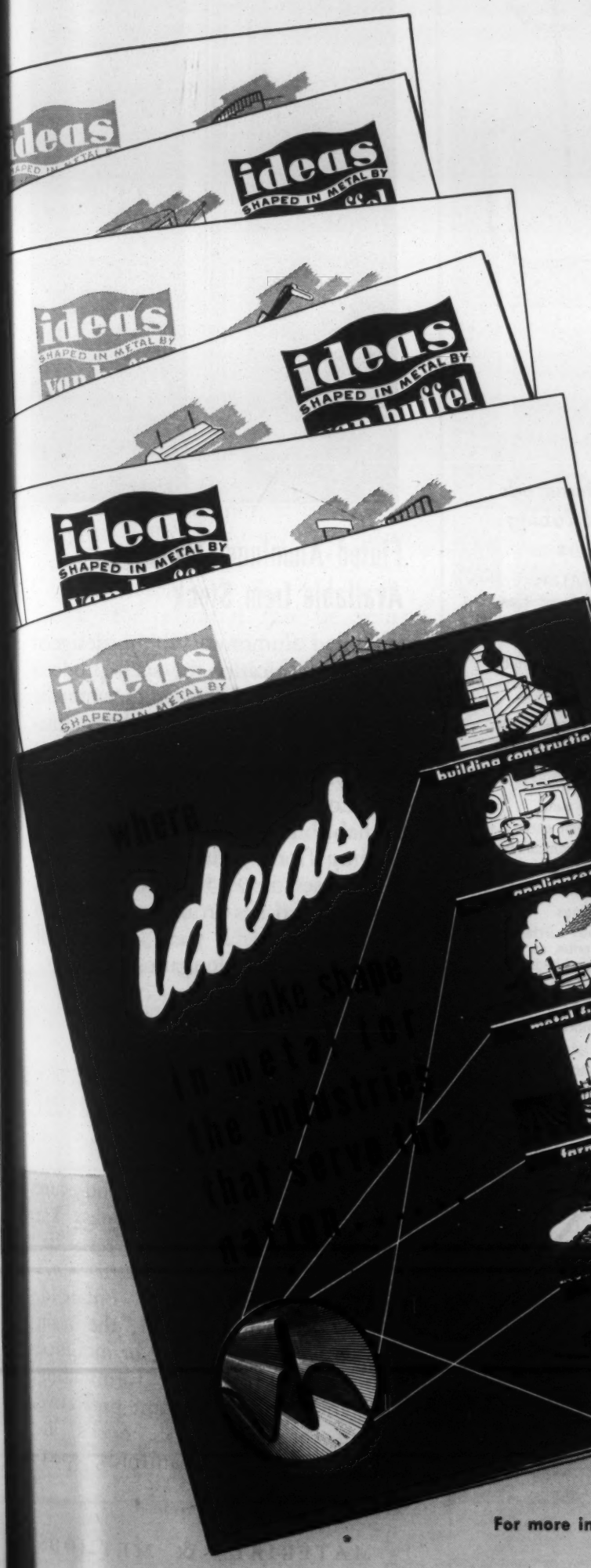
Adhesion value is obtained at a stripping speed of 12 in. per min from a stainless steel panel. Tape is applied by rolling with wallpaper roller until smooth.

(Continued on page 174)

looking for



metal furniture ideas?



Could be you are overlooking a good bet if you aren't familiar with what Van Huffel can do in cold forming metal shapes and tubing.

To give you a better picture of how other manufacturers are cutting costs and improving their products, we have prepared a portfolio of ideas that should be in your file. It's yours free for the asking.

FREE FOR YOUR FILES

VAN HUFFEL TUBE CORPORATION MF-410
WARREN, OHIO

Please send me the METAL FURNITURE idea portfolio

NAME .....

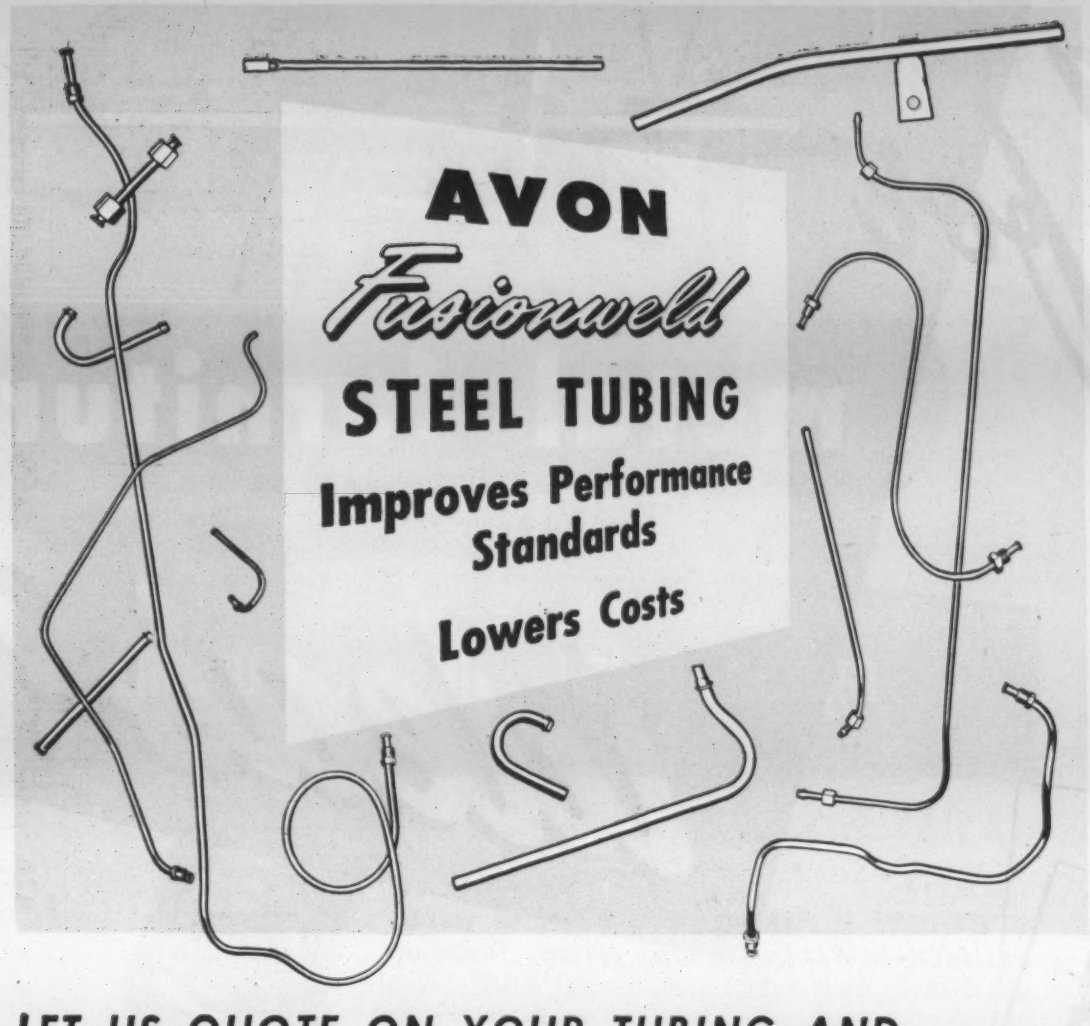
TITLE .....

COMPANY .....

ADDRESS .....

CITY ..... STATE .....

For more information, Circle No. 385

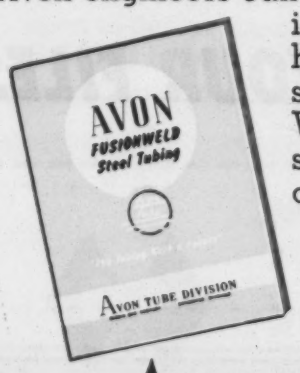


LET US QUOTE ON YOUR TUBING AND FABRICATION NEEDS

Avon single wall steel tubing is successfully supplanting other types of tubing—aluminum, brass, copper and steel—with equal or improved reliability of performance and really impressive economies.

Avon's High Frequency Fusionweld process insures a much higher degree of tensile strength, greater resistance to vibration and fatigue, extreme ductility, plus greatly improved adaptability in producing the most critical tube forms—such as beading, bending, coiling, flaring, knurling, slotting, piercing, threading and swaging without cracking, tearing or checking.

Avon engineers can assist with your tubing problems and help point up cost saving advantages. Why not write, or submit blueprints for quotations.



A few of the hundreds of Fusionweld Tubing applications

AUTOMOTIVE
Gas lines & vents
Brake lines
Hydraulic window & seat lifts
Chassis tubes
Radiator overflow
Choke controls
Oil return lines
Dip stick tubes
Oiler tubes
Automatic transmission

FARM EQUIPMENT
Hydraulic lifting devices
Support tubes
Lubrication lines
Fuel lines
Fuel manifolds

ELECTRICAL
Ceiling & wall fixtures
Lamp tubes
Heating elements
Radio & TV antennae

HEATING
Oil & gas lines
Pilot tubes
Flash tubes
Pot burner tubes
Fuel tank tubes

TOYS—FURNITURE
Scooter & wagon parts
Spacers
Pop guns
Bicycle parts
Mechanical toys
Tables
Chairs
Swings
Baby carriages, cribs, car seats and beds

MISCELLANEOUS
Umbrellas
Display boards
Panels
Conveyor oil lines
Lawn mower handles
Hose reels

3/16" O.D. to 3/4" O.D.
PLAIN OR TERNE COATED

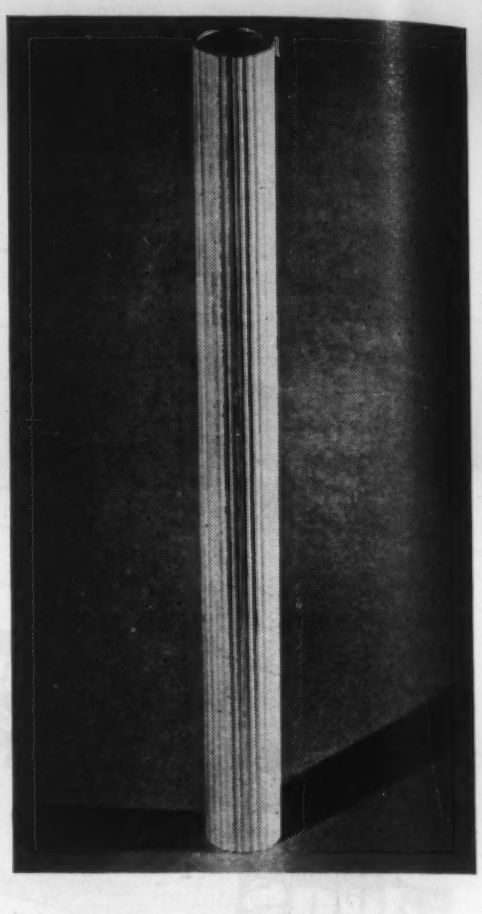
AVON TUBE DIVISION

HIGBIE MANUFACTURING CO.

ROCHESTER MICHIGAN

For more information, turn to Reader Service Card, Circle No. 313

New Materials, Parts and Finishes



Fluted Aluminum Tubing Available from Stock

Fluted aluminum tubing, designed for the fabrication of such products as furniture, clothes, poles, umbrella handles, ladder rungs, and for ornamental use is now available from *Reynolds Metal Co.*, 2500 S. Third St., Louisville, Ky. The tubing is available in outside diameter sizes ranging from 3/4 to 1 in., with wall thicknesses of 0.050 up to 0.062 in. The material has an ultimate strength of 32,000 psi, a yield strength of 25,000 psi, and elongation of 8%.

New Silicone Resin has High Heat Resistance

High heat resistance, good cure speed, flexibility and hardness are claimed for a new silicone resin developed by *General Electric Co.'s* Silicone Products Dept., Pittsfield, Mass. Designated SR-111, the resin is designed for use alone or modified with organic resins for formulating heat- and weather-resistant protective coating for smokestacks, ovens, incinerators, exhaust manifolds, space

New Materials, Parts and Finishes

heaters and jet engine components.

According to G-E, colored formulations based on the new resin show no color change and retain most of their initial gloss for more than 10 wk at temperatures up to 500 F on both steel and aluminum. The good compatibility of the resin with organic and other silicone resins makes it suitable for use in both colored and aluminum finishes, and allows paint formulators greater flexibility in their choice of modifiers than is offered with other silicone resins.

Insulating Material Protects Tools

Designed as a dipping compound to provide insulation and abrasion resistance for electrical tools, E-33 is said to eliminate the need for taping tool handles or purchasing tools equipped with non-conductor handles. Marketed by the *Insl-X Sales Co.*, 26 Rittenhouse Sq., Ardmore, Penna., the material can be reinforced and built up to practically any dielectric strength desired. The compound is chemically inert, and will not corrode or injure any equipment to which it is applied, according to the manufacturer.

Tools to be protected need only be dipped and allowed to drain and dry. Three successive coats, an hour apart, are recommended for 110 to 220 v exposure. Dielectric strength for a 1-mil coat (dry) is 1200 to 1500 v. The compound is available in either red or black.

Tungsten Carbide Forms have High Accuracy and Finish

Smoother surfaces and closer tolerances are claimed for a new line of hot pressed tungsten carbide shapes being produced by the *Sintercast Corp. of America*, 134 Woodworth Ave., Yonkers 2, N. Y. Designated the Sinterforge SF line, use of the parts is said to allow savings in finishing costs.

Sinterforge SF is available in all

For more information, Circle No. 370 ➤

put real sales appeal in your products with MUELLER BRASS CO. forgings

Windows in this modern new Florida hospital supplied by Valley Metal Products Co.—subsidiary, Mueller Brass Co.

The aluminum hardware used on all the windows in this modern hospital is a good example of the sales appeal that can be built into a product with Mueller Brass Co. forgings. These forgings are smart in design, practical in operation, and low in cost. They can also be produced in natural bronze or chrome finish depending on the desires of the architect or builder.

All Mueller Brass Co. forgings have a dense, close-grained structure with a high tensile strength. Weight savings up to 40% are possible in the design of parts because of the close tolerances to which they can be produced. Less scrap and longer tool life result from the easy machinability of forged parts. Mueller Brass Co. is completely equipped to produce brass, bronze or aluminum forgings to your specifications. For complete details, write us today.

MUELLER BRASS CO.

PORT HURON 16, MICHIGAN

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New Materials, Parts and Finishes

grades of tungsten carbide that are conventionally used for hot pressed products. This includes the range of cobalt contents from 6 to 20%. The process is particularly applicable to the high cobalt (binder rich) compositions where ordinary hot pressed surfaces are roughened by "sweating out" the binder. Parts produced by the new method are said to have improved uniformity of structure and diminished porosity.

Typical examples of Sinterforge SF parts are drawing dies, bushings, mandrel tips and core rods for powder metallurgy. According to the company, the finished parts result in substantial savings compared to regular hot-pressed products due to reduction in time, labor and grinding materials, although the unit cost of the "as pressed" part is slightly higher.

Flexible Plastic Pipe has Good Weatherability

A flexible plastic pipe made of a new polyethylene which is said to withstand the deteriorating effect of sunlight is being produced by *Munray Products, Inc.,* 12400 Crossburn Ave., Cleveland, 11. According to the manufacturer, the pipe is produced from virgin materials with no anti-oxidants or pigments which might make it toxic.

The pipe can be used either buried or above ground for a variety of domestic, farm, industrial, chemical and food processing applications. As well as being sunlight resistant and non-toxic, the pipe is said to be resistant to corrosion, rust and rot, to have a low friction loss, and to be immune to corrosive waters, soils, and a wide range of chemicals including most solvents. Munray pipe is said to be flexible enough to permit bending around most obstacles without kinking, and to be light in weight. The pipe is available in 9 standard sizes up to 6 in. in diameter, and Munray fittings are available for simple installation.

another ROGERS innovation

"Tepee" test of paper-base laminates, with ten-inch flame applied for two minutes.

At left, standard grade continued to burn after flame was removed. It was completely destroyed. At right, flame-resistant Rogers grade extinguished itself in less than eight seconds and retained most of its structural strength.

WORK-HORSE MATERIALS MADE FLAME-RESISTANT

BY WORK-HORSE, we mean our paper-base laminates, which are now available with exceptional flame-resistant qualities. The main purpose of these materials is to reduce costs in applications that now require glass-base laminates.

We have also added flame-retardant properties to our DUROID 800, a fibrous insulating material, listed by Underwriters' Laboratories as suitable for the sole support of current carrying parts. DUROID 800 is also self-extinguishing, but will not withstand as severe burning as our flame-resistant laminates.

Since industry-wide specifications for flame-resistant or flame-retardant materials do not exist, each of these Rogers materials should be assessed in terms of your application. Complete data are available, and we will be glad to supply samples for your own testing purposes.

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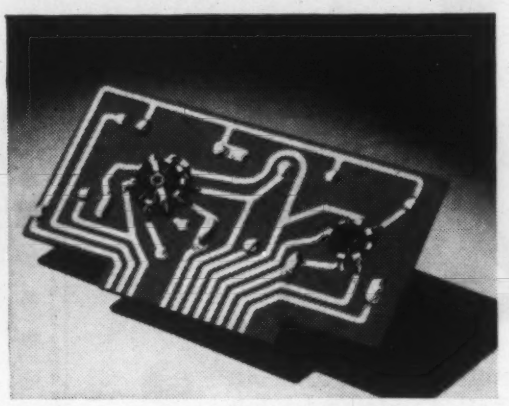
Get better printed circuits . . . lower costs . . . fewer rejects

with NEW C-D-F METAL CLADS

All manufacturers of metal clad stock for printed circuitry have made considerable progress in improving their product—a material with a metal foil surface bonded to a non-conducting base. How this has been done by one leading manufacturer, the Continental-Diamond Fibre Company, illustrates some of the problems involved in buying this type of material and in understanding its design potentials.

C-D-F CONSOLIDATED GRADES

At first, small test lots of Dilecto laminated plastic with copper surfaces were made. Almost every core material was used. Finally the number of practical grades for printed circuit work narrowed down to these few grades which retained to a large degree the inherent electrical qualities of their base material and resin at high temperatures:

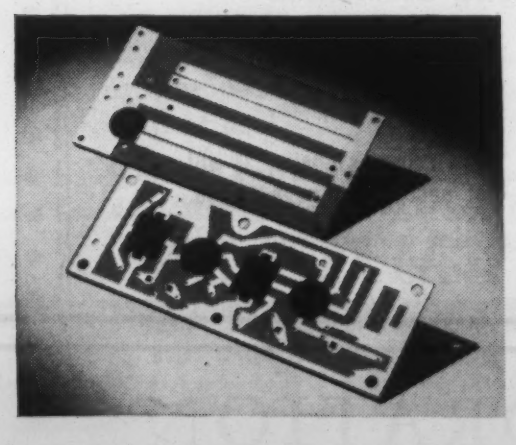


COPPER CLAD GRADE XXXP-26

A laminate with excellent electrical and mechanical properties. High moisture resistance and dimensional stability. Recommended for applications where high heat and high insulation resistance plus low dielectric loss under high humidity is needed. Low cold flow characteristics. Can be hot punched to ⅛″. Good flexural strength. Natural green color.

This is one of the *improved C-D-F Dilecto laminates.* Advances in resins and manufacturing techniques makes this grade almost homogeneous, with improved impregnation of the filler. Thorough impregnation eliminates entrapped moisture and air, giving greater moisture resistance and better dielectric properties.

Any metal clad is no better than its base and the care taken in laminating. With the cost of material high, compared to labor and inspection, the purchase of a *uniform* metal clad material, like this C-D-F grade, becomes vital.



COPPER CLAD GRADE XXXP-24

Similar to grade XXXP-26 in electrical and moisture resistance properties, but not quite as strong mechanically. Equal cold flow and punching characteristics. Natural brown.

COPPER CLAD GRADES GB-112S AND GB-261S

These silicone grades use a glass fabric laminate with a copper foil surface on one or both sides. Recommended where high heat resistance and low dielectric loss properties are required. For certain tuners and inductances the low dielectric loss factor of this grade makes its higher cost acceptable. A continuous filament (Grade GB-112S) is used for thicknesses 1/32 to 1/16″. A staple filament (Grade GB-261S) is used for thicknesses over 1/16″.

COPPER CLAD GRADE GB-116T

A glass base laminate using duPont's tetrafluoroethylene resin, Teflon, for outstanding resistance to high heat with extremely low dielectric loss properties. A fine weave continuous filament glass fabric cloth is used for superior mechanical strength and good machining qualities. In spite of its high cost, this C-D-F grade has demonstrated that it can save money and do a job that no other single material can in microstrip high-voltage, high-frequency circuit elements. Remember, C-D-F is a major supplier of sheets, tapes, rods, tubes of Teflon, has valuable experience in its manufacture and fabrication. Write for samples.

C-D-F INCREASED BOND STRENGTH

By developing a special thermo-setting adhesive particularly suited for metal clads, C-D-F was able to increase the bond strength of their laminates considerably above their original figures. Bond or peel strength, the amount of pull required to separate the foil from the core material, is one of the most important physical properties. Therefore, the purchaser should compare his source of supply with these C-D-F average test values:

BONDING STRENGTH—FOIL TO LAMINATE

MATERIAL	Average or Typical Value Lbs. pull per 1″ width of foil to separate
XXXP-24 or XXXP-26 plus 0.0014″ copper	5 to 8
XXXP-24 or XXXP-26 plus 0.0028″ copper	7 to 9
GB-116T plus 0.0014″ copper	5 to 12
GB-112S plus 0.0014″ copper	6 to 8
GB-261S plus 0.0014″ copper	7 to 10

These values are based on tests at prevailing room temperature (20-30°C.)

C-D-F INCREASED HEAT RESISTANCE

Special efforts by C-D-F technicians to increase the heat resistance of all C-D-F Metal Clads have resulted in certain special grade variations able to withstand higher soldering temperatures without damage. As production methods change, C-D-F offers materials to meet your requirements.

NOW . . . HOW ABOUT YOUR STORY?

Notice how we have talked about C-D-F and what we have done to improve quality and uniformity of metal clad products. Much of this has been accomplished with the guidance and cooperation of leading users of printed circuit stock. No one company knows all the answers . . . but C-D-F, a big reliable source of supply, can help you get better printed circuits . . . lower costs . . . fewer rejects. Look up the address of your nearest C-D-F sales engineer in Sweets Design File, write us for samples you can test in the lab and on the production line, technical bulletins, help on your specific project. We want to work with you!

CDF Continental-Diamond Fibre

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Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- *Intermetallics for High Temperatures*
- *SAP: Effect of Powder Size and Oxidation*
- *Properties of Four Cermets*
- *French Comparison of Boron Steels*
- *Plastics for Refrigerators*

Nickel-Aluminum Alloys for High Temperature Use

Intermetallics are known to possess properties radically different from those of their constituent elements, and many are quite stable at elevated temperatures. Elevated temperatures here are defined as the range of 1500 F and over. For example, one nickel-aluminum alloy recently investigated (Guy's alloy) has a 100-hr stress rupture strength of 50,000 psi at 1500 F.

In order to gain more information on the nickel-aluminum intermetallics, an investigation was carried out at the Lewis Flight Propulsion Laboratories of nickel alloys containing 14 to 34% aluminum, and a report by W. A. Maxwell and E. M. Grala was published by the National Advisory Committee for Aeronautics last August.

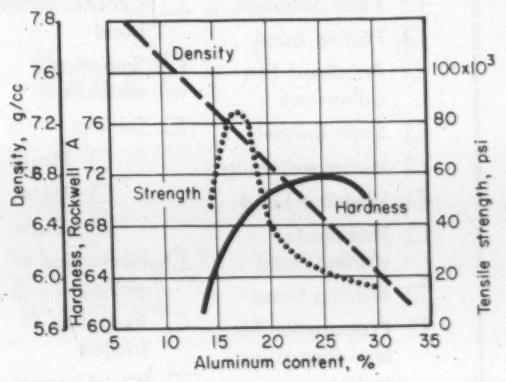
Properties of Optimum Alloy

Of the alloys tested, the one found to possess the optimum properties was the 17.5 aluminum, 82.5% nickel. The tensile properties of this alloy are shown in the accompanying table. The addition of grain-refining agents to the alloy did not improve strength properties, though they did alter grain size to varying degrees. The stress-rupture properties are slightly better than Inconel, but inferior to Inconel X. According to the authors, the high creep rates of the alloy may be due to the absence of a finely dispersed precipitate. And if the creep rates can be reduced by slight alloying additions which form a precipitation-hardening phase, a useful alloy could result for creep-rupture applications.

Notched impact strength of the alloy was found to be around 3.5 in.-lb at room temperature, while unnotched impact strength ran over 10 in.-lb. Although the measured impact values would indicate that the material behaves like cermets, specimens did not fracture completely on impact indicating that the alloy has some inherent ductility. The ability of the material to withstand thermal shock was found to be adequate for turbine-blade applications, since it resisted over 200 cycles of thermal shock testing under conditions simulating jet-engine blow-out conditions. In oxidation resistance it was found to be slightly better than Nichrome at 1800 F and superior to the high temperature alloys, S816 and Inconel X.

Metallurgical Considerations

In the alloys tested, both NiAl and Ni_3Al phases were detected by x-ray techniques. The alloys other than the 17.5 aluminum contained either one phase or the other, while the 17.5 aluminum alloy contained both phases. Alloys containing only the Ni_3Al phase are hard and brittle, although they have some ductility. As-cast specimens exhibited room-temperature tensile strengths of around 48,000 psi with 2.5 to 6.3% elongation. At 1500 F, the tensile strength was around 37,000 psi with



Increasing aluminum content has a substantial effect on properties of nickel-aluminum intermetallics.

Tensile Properties of 17.5% Aluminum-Nickel Alloy At Room Temperature and 1500 F (Original condition, as-cast)

Heat Treatment	Addition	Ten Str., 1000 psi		Extens. Elong, % (Room Temp.)	Total Elong, % (1500 F)
		Room Temp.	1500 F		
None	None	83.8 79.6	52.9	0.6 0.6	2.9
Homogenized 16 hr, 2400 F	None	94.3	37.6	0	0.9
Homogenized 48 hr, 2000 F	None	33.4	55.3	0	2.5
Rolled 50%, 2400 F	None	86.3 82.7	50.0 51.7 21.0(a)	0 —	4.4 3.5 25.0
Rolled 25%, 2400 F 13%, 2200 F	None —	69.6 —	40.4 —	0 —	1.3 —
None	5.0% Mo	88.6	51.2	0.2	2.0
Rolled 34%, 2400 F	5.0% Mo	84.4	55.0	0.4	2.8
None	0.3% Ti	84.3	56.0	0.4	3.9
None	0.05% B	92.6	43.8	—	2.5

(a) Test temperature, 1800 F.

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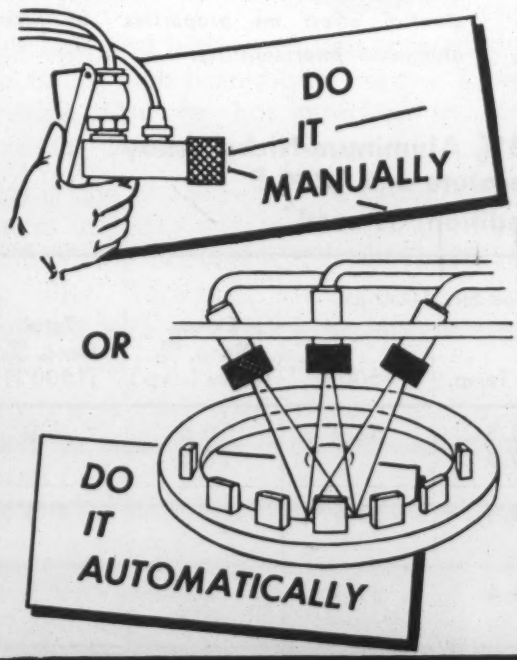
- ☐ Stress relief
- ☐ Vinyl coating bond
- ☐ Ceramic coating bond
- ☐ Smoother surfaces
- ☐ Etching
  - ☐ Plastic
  - ☐ Metal
  - ☐ Glass
- ☐ Elimination of galling
- ☐ Reduction of friction
- ☐ Visual inspection



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elongation of 1.3%. In all cases the material was found to be hot-short.

An alloy containing only the NiAl phase (25% aluminum) had a room temperature tensile strength of 22,000 psi with no measurable ductility. At 1500 F, the strength of the alloy had increased to 31,800 psi with a 3.8% elongation.

Although the 17.5 aluminum alloy contained both phases at room temperature, heat treating at 2400 and 2500 F caused complete solution of the Ni_3Al phase into the NiAl matrix. Cooling conditions caused the nucleation of a Widmanstatten phase at the grain boundaries with a martensite-like phase within the grains.

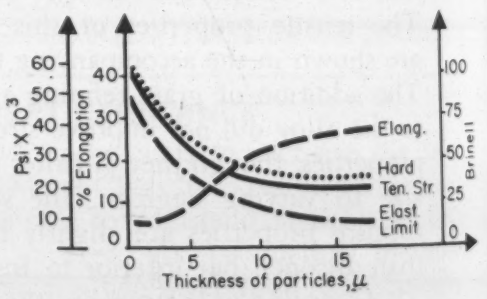
Properties of SAP

Sintered compacts of oxidized aluminum powder (SAP) have aroused much interest lately because they show better strength at elevated temperatures than do wrought aluminum. The superior properties of the compacts seem to be due to the network of aluminum oxide surrounding the particles; therefore, particle size is a determining factor in respect to room and elevated-temperature properties of the material.

In an article in the Apr. 1954 issue of *Revue de Metallurgie* (French), J. Herenguel and J. Boghen report on their investigation of the specific effect of the size and degree of oxidation of the powder on the properties of the compacts. They also determined the effect of plastic deformation as interrelated to these factors. Thickness being chosen as characteristic of the size of the flake powder used, the authors found that increasing flake thickness caused a decrease in room-temperature strength with a roughly inverse increase in elongation. Increasing the thickness also had a deleterious effect on elevated-temperature strength. The oxide film should be thick enough to coat the particles; but excessively thick films cause no further improvement in properties and may be a hindrance in processing.

Effect of Forming Operations

The effect of deformation on the properties of the compact is a function of the degree to which the oxide film structure is disturbed. Cold working the sintered compacts had little effect on room-temperature properties, but reduced the strength at 600 F. Hot working somewhat decreased room-temperature strength with a simultaneous improvement of ductility. At 600 F, however, small degrees of hot working greatly increased the life under a given load with little effect on ductility. Greater degrees of reduction caused a sharp



Effect of particle thickness on properties of sintered aluminum compacts.

How Particle Characteristics Affect Properties

Characteristics of particles		Test Temp, F	Behavior under Load (5700 psi)	
Thick., μ	Oxide Thick., μ		Life	Elong at Fail., %
3.5	0.024	575	100 hr	no failure
—	—	850	100 hr	no failure
—	—	930	1 hr	1.0
8.0	0.022	575	13 hr	6.5
15.0	0.025	575	20 min	18.0

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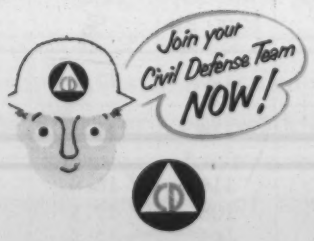

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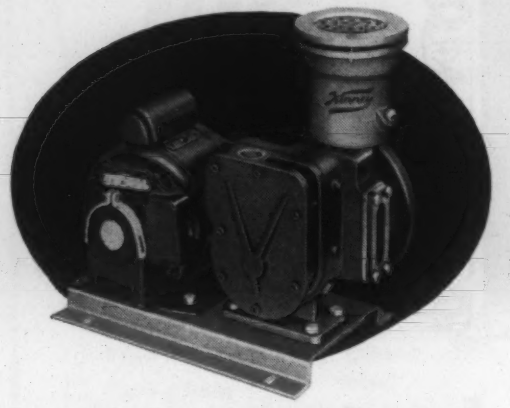
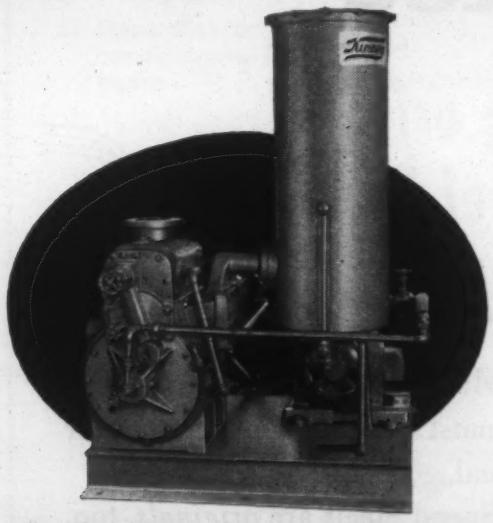
Kinney offers you the big line of vacuum pumps — four Compound Models . . . nine Single Stage Models. Whatever your vacuum processing problem, you will find it pays to consult with Kinney.



Compound Vacuum Pumps

MODEL NO.	THEO. DISPL.	MOTOR H. P.	FORMER MODEL NO.
KC-2	2.0	¼	CVM 3153
KC-5	4.9	⅓	CVM 3534
KC-15	15.2	1	CVM 5- 5- 6
KC-46	46.0	3	CVM 8- 6-10



Single Stage Vacuum Pumps

KS-13	13.0	½	VSM 5- 5- 6
KS-27	27.0	1½	VSM 7- 7- 8
KS-47	46.8	2	VSD 8- 8-11
KD-110	110	5	DVD 8- 8-10
KDH-130	131	5	DVH 8- 8-10
KD-220	218	10	DVM 12- 8-14
KD-310	311	15	DVD 14- 9-18
KD-485	486	25	DVD 14-14-18
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Contents Noted

Cermets . . .
Boron Steels . . .

drop in strength, while still higher degrees of reduction gave much higher ductility.

Although variations in particle thickness seem to have little influence on the relative effect of hot working, the best properties were obtained with compacts made with the thinnest particles. Thickness of the oxide film had little effect on room-temperature properties after hot working, but the improvement in strength at 575 F was most noticeable with the thickest films.

Though the authors foresee the possibility of manufacturing large, drawn or rolled, semi-finished products of SAP, they emphasize that the desired properties and the deformation to be used in processing must be taken into consideration in selecting the type of powder to be used.

Four Titanium Carbide Base Cermets

With the widespread current interest in cermets, an investigation was carried out at the Langley Aeronautical Laboratory to determine the mechanical properties at room temperature of four titanium carbide-base cermets which utilize a nickel binder. In a report by A. E. Johnson, Jr., published by the National Advisory Committee for Aeronautics last Aug., the table shows properties of materials determined by testing.

Properties of Four Titanium Carbide Cermets with Nickel Binder

Comp., % TiC-Ni	95-5	90-10	80-20	70-30
Ten. Str, 1000 psi	38 37.5	65.5 72	74 77.5	115 118
Comp. Str, 1000 psi	330 327	353 349	350 351	337 335
Shear Str, 1000 psi	36 (a)	56 74	89 95	101 99
Hard. Rock. 30-N	88	88	84	79
Dens., lb/cu in.	0.171	0.178	0.190	0.200
Comp. Yld Str, 1000 psi	—	—	286 299	238 235

(a) No test.

French Compare Properties of Boron Steels

The main effects of boron in steels appear to be improvement of hardenability, which causes a general improvement of mechanical properties

Dia, in.	Specimen Location	0.61 Cr-0.12 Mo-0.58 Ni + B			0.58 Cr-0.13 Mo-0.56 Ni		
		Ten. Str, 1000 psi	Elong, %	Imp. Str, ft lb*	Ten. Str, 1000 psi	Elong, %	Imp. Str, ft lb*
1.0	core	119	15.5	34	120	15.5	39
2.0	core	117	16.5	37	114	17.5	44
3.9	surface half rad. core	119 116 110	15.3 15.0 16.3	34 34 —	114 108 105	16.8 17.5 17.5	35 34 —
7.9	surface half rad. core	120 112 108	14.0 15.3 16.0	26 21 —	111 108 103	17.0 18.3 17.5	30 27 —

Specimens oil quenched from 1560 F and tempered at 1020 F for Cr-Mo-Ni + B and 930 F for Cr-Mo-Ni.
** Type C specimen (ASTM E 23-47T) broken in a simple-beam machine.*

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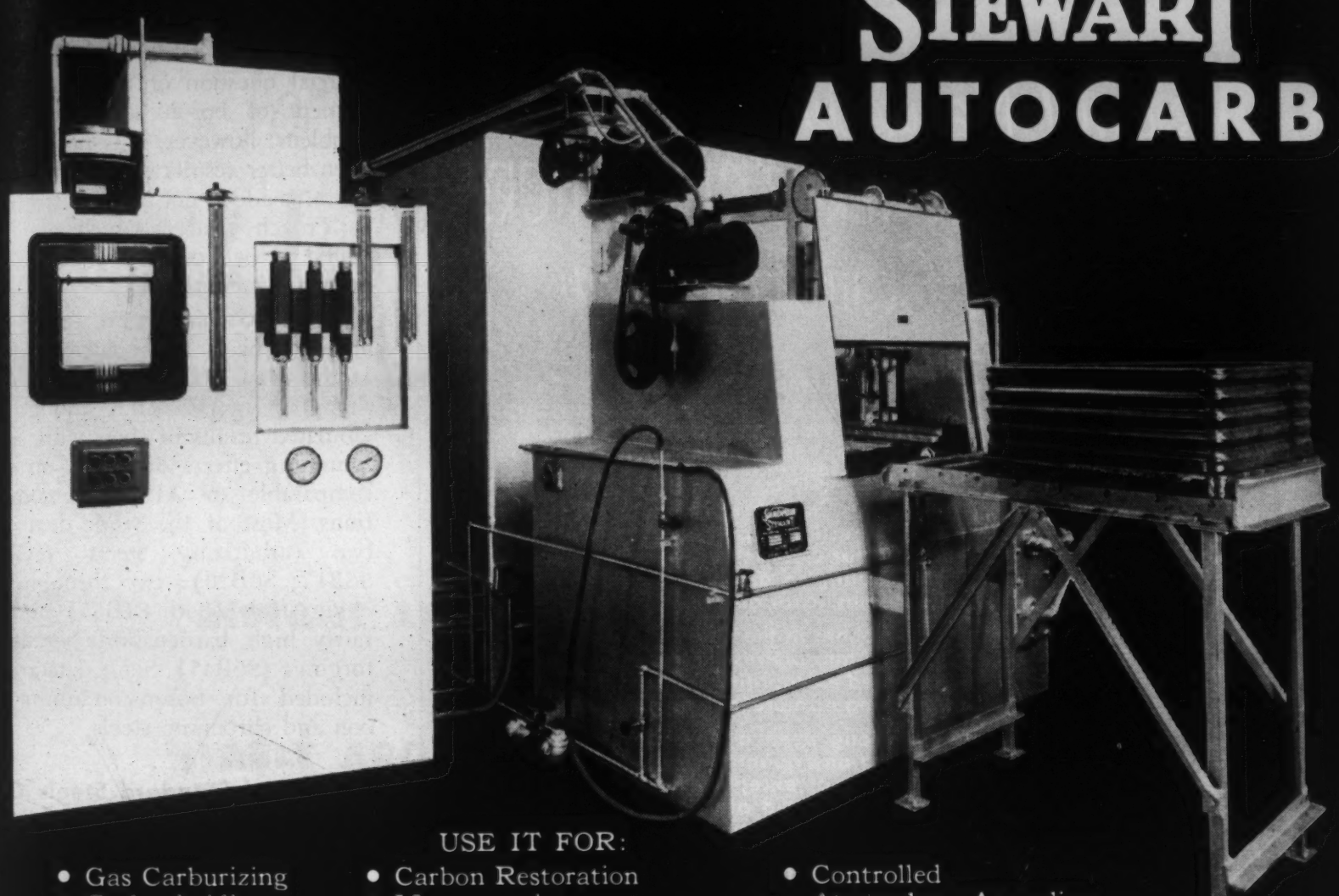

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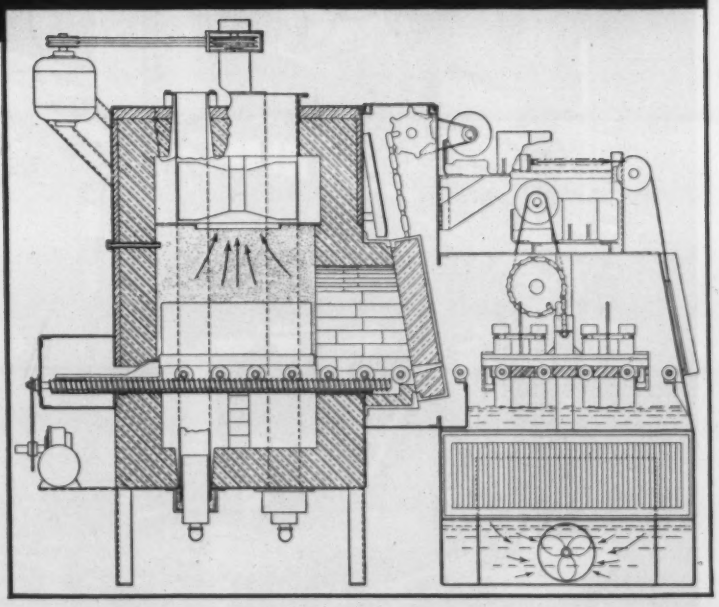

Cross section view of the Sunbeam Stewart AUTOCARB—The All-In-One furnace that pays for itself quickly. Has a completely enclosed heating chamber with heat distributing and capacitor refractories for efficient uniform operation. Easy-to-replace, light weight radiant tubes.

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For more information, turn to Reader Service Card, Circle No. 375

ANNEALING ALUMINUM STRIP IN CONTROLLED ATMOSPHERE

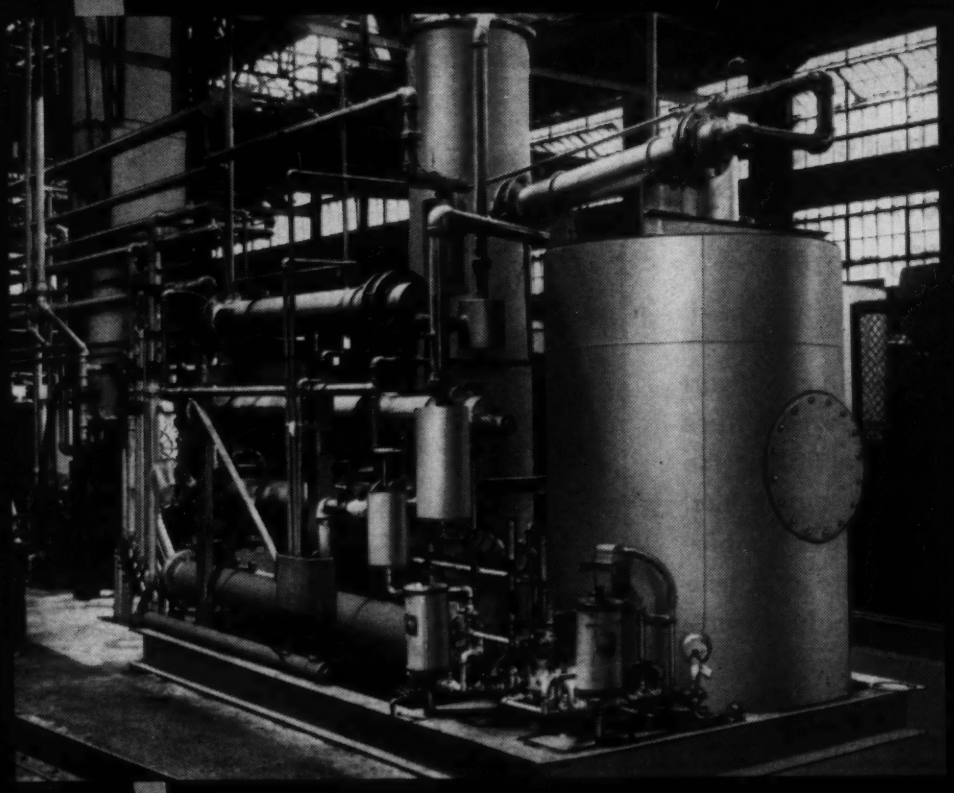
Scovill Manufacturing Co. Selects GAS ATMOSPHERES' GENERATORS To Produce Stain-Free Strip

The Scovill Manufacturing Company of Waterbury, Conn., long a leader in producing quality copper-base alloy strip, recently put the finishing touches to the first production installation of a controlled atmosphere aluminum strip annealing system.

This new system enables Scovill to produce controlled grain sizes, tempers, directional properties and dimensions in aluminum strip far closer than was once thought possible. And, by annealing in a controlled nitrogen atmosphere, the strip retains its original brightness.

To get the purest atmosphere in the shortest possible time Scovill selected a Gas Atmospheres' Nitrogen Generator which has since delivered extraordinary production economy ratios while requiring no more than initial adjustment.

Gas Atmospheres has long been a supplier of compact generators for producing any quantities of controlled annealing atmosphere gases at exceptionally low cost. So when next considering generated atmosphere remember it will pay you to consult Gas Atmospheres before you buy. Representatives in leading metal producing areas.



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after quenching and tempering. This indicates that boron steels may be used in many cases to replace more highly alloyed steels. The purely commercial question of industrial development of boron steels remains a problem; however, it is possible that even better results can be attained if boron is added not to U. S. steels, but to French grades, which are more suited to that country's industrial and economic conditions.

These conclusions are reported in an article by G. Delbart and A. Kohn in the May 1954, issue of *Revue de Metallurgie* (French), along with tabulated results of their work in determining effects of boron on steels comparable to AISI-SAE compositions. Most of the work dealt with two carburizing steels (94B17/86B17; 80B20); two through-hardening steels (both 81B35) and one fairly high hardenability grade for forgings (86B45). Some data are also included for boron-containing carbon and chromium steels.

Boron and Standard Steels Compared

A comparison of these boron-containing steels with standard French grades which give equivalent hardenability and properties show the effect of boron in replacing other alloying elements. This can be represented schematically as follows:

Carburizing Grades:
B + 0.17% Mo=0.3 Cr-0.6% Ni
B + 0.25% Mo=0.6 Cr-1.0% Ni
Through-Hardening Grades (about 0.35% carbon):
B+0.15% Mo=0.4 Cr-1.0% Ni
B+0.30% Ni=0.5 Cr-0.10% Mo
Low Carbon Grade:
B=0.2 Cr-0.25% Mo

With medium-carbon steels, the effect of boron in improving mechanical properties is observed only when the section is greater than a certain limiting value, which depends on the rest of the analysis. In smaller sections, the same steel without boron will harden through, so no advantage is gained. And, in extremely large sections, where neither the boron nor the boron-free steel hardens through, the efficacy of boron diminishes. Since this increase in hardenability is found at tempering temperatures under 1100 F, carburizing steels would appear most promising because of

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their low tempering temperature. However, boron carburizing steels are said to be more sensitive to deformation in hardening and to spalling in the carburized case.

Future of Plastics in the Refrigeration Industry

Though using a large volume of plastics at present, the refrigeration industry expects to double its use of plastics on each appliance within the next 10 years. This increased usage must be accompanied by developments in the plastic materials themselves. In a paper delivered before the Annual Conference of the Society of the Plastics Industry, last June, R. E. Wallenbrock pointed up the materials developments which the refrigeration industry is looking for in the field of plastics. The properties of plastics which make it an attractive engineering material for the industry are its low cost, light weight, attractive colors, its ability to be formed into complex shapes, and its insulating effect.

General Needs

According to the author, a better liaison between the materials research and development groups and the industry would help in engineering plastic materials for their proper use. Better plastics grading methods, specifications and industrial standards are desired. More complete technical data should be supplied than is currently available on physical properties of plastics, both new and old materials. The industry is interested in techniques which will improve methods of fabrication of small run prototype production.

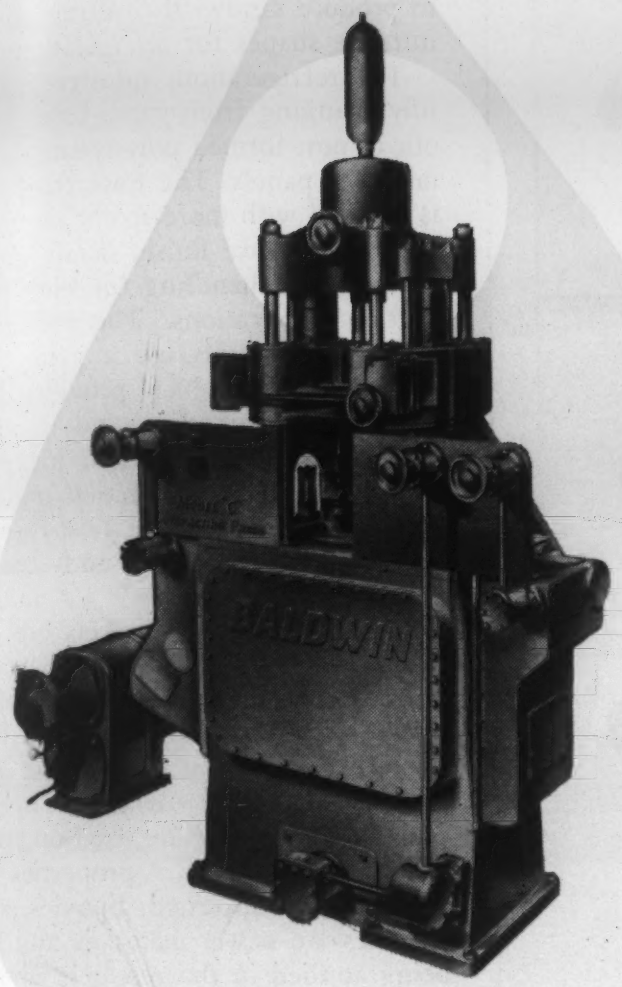
Some examples of industrial needs along the line of improved materials are: 1) Polystyrene—less breakage, and better post-forming properties; 2) Reinforced polyester—mass production techniques; 3) Vinyl gaskets —better recovery, lacquer resistance and compatability with polystyrene, and 4) Acrylics—lower cost.

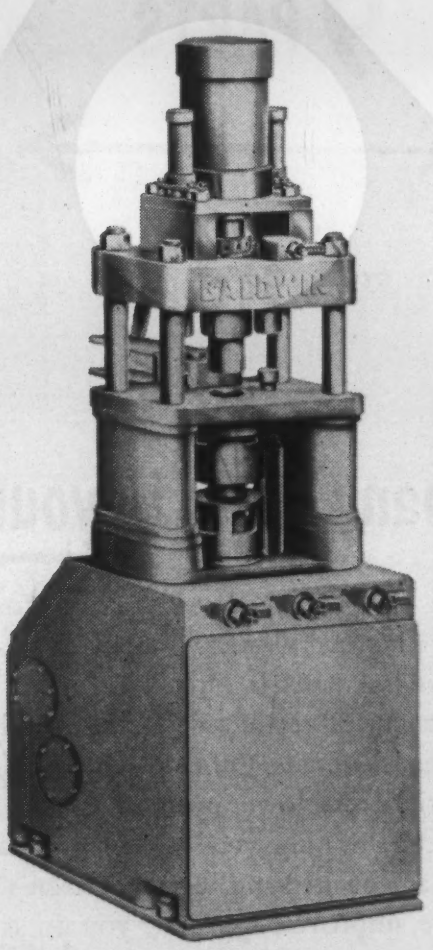
Glancing Ahead

The foams are of particular interest to the industry. Recent progress made in foaming polystyrene in place is encouraging from the design standpoint. According to the author,

HYDRAULIC HEAD

avoids overloading, controls densities, in new Baldwin powdered metal presses . . .





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3. It permits use of more delicate tools.

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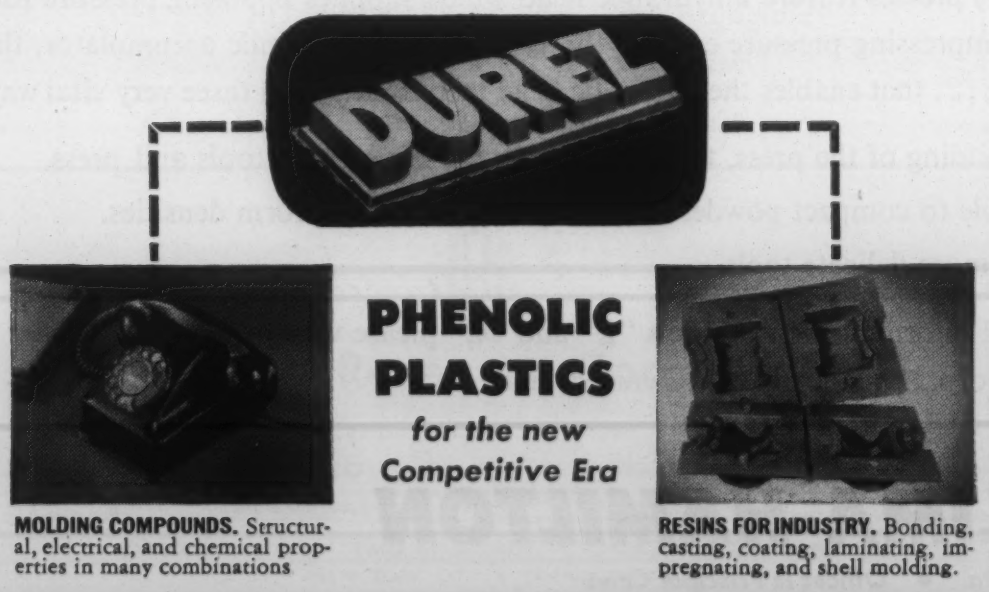

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Contents Noted | High Temp Materials...

it may be practical to combine foams with thin post-formed plastic skins to produce sandwich constructions in intricate shapes for refrigeration use.

The refrigeration industry is rapidly changing from paper-base phenolic to post-formed polystyrene on inner door panels. The lower tool cost is coupled with more recent improvements in surface finish, detail, depth of form and handling for high production applications. The refrigeration manufacturers use a great deal of polystyrene, which provides low temperature properties, and is odorless, tasteless, colorful and inexpensive. It is used for injection molded parts, extruded parts, post-formed parts, and calendered and coated parts.

Polyvinyl chloride gaskets are extruded, cut and heat-joined at the mitred corners in simple, economical operations. Vinyls are being used as door coverings, trim strips, foam and sealing materials. Acrylics, nylon, phenolics and ureas are used on parts requiring the specific properties of the material concerned. Epoxies, and silicones are newer materials and are being applied in the research laboratories to determine the future needs they might meet.

Higher Temperature Materials Mean Higher Jet Performance

Higher temperatures in the gas turbine of a turbojet power plant mean tremendous increases in efficiency, and thus power. At present, these aircraft turbines operate at temperatures of around 1550 F. Aeronautical engineers are searching for materials for turbine parts which will withstand a temperature of 2500 F. Should these materials be developed, they say, 60% more thrust or jet power would be obtainable from an engine of the same size and airflow capacity. Conversely, the present power output could be achieved with a smaller engine, thereby greatly reducing the size and weight of the aircraft.

These facts are pointed out in a brief article in the Aug. 1954 issue of the *Battelle Technical Review* which goes on to emphasize the promise that ceramic materials hold out in the stretch for higher temperature materials. At the present time, efforts are being concentrated on increasing the safe operating tempera-

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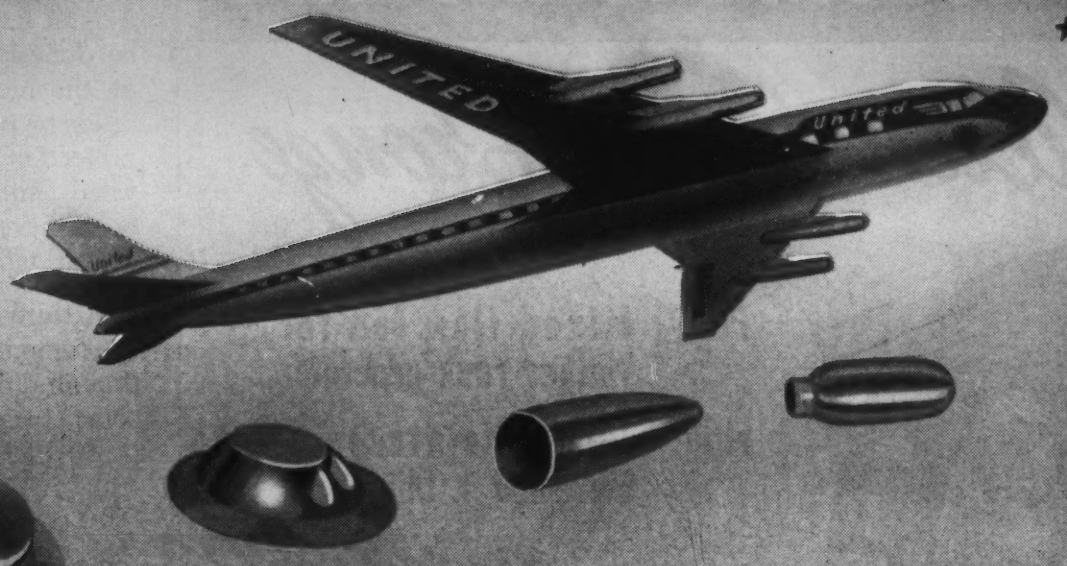

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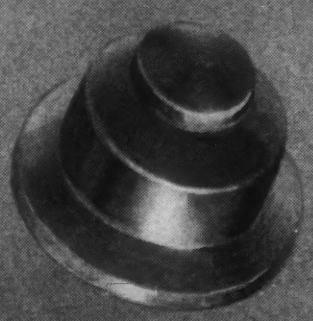

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★ Illustration taken from "The Next Fifty Years of Flight" by Bernt Balchen and Erik Bergaust, published by Harper & Brothers.

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Part: Mixed flow fan for Walker tank generator

Mfgr: Jack & Heintz, Inc., Cleveland 1, Ohio

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This intricate part, with 17 vanes only .093" thick and 2½" long, required smooth surfaces for efficient cooling, high strength and balance for an operating speed of 8000 rpm, and corrosion resistance for operation in all kinds of weather, even under water. The exclusive vacuum die casting process developed by the Aurora Metal Company and an AUR-O-MET Aluminum Bronze alloy met and surpassed these requirements.

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The sound, dense, high tensile strength vacuum die casting produced the fan so it would stand up under constant tough field operation. The 7" diameter fan even withstood spin tests at 17,000 rpm.

DESIGN FREEDOM

Because of high-strength, sound, smooth castings, the fan vanes could be made to an optimum thickness with this casting method. This enabled Jack & Heintz's engineers to provide a more efficient cooling flow.

LOWER FINAL COSTS

Freedom from oxide inclusions, exclusive with the vacuum die casting process, made machining simple, fast and inexpensive. Uniformity reduced time necessary in final balancing and the smooth cast surfaces eliminated further finishing.

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ture of severely stressed turbine parts by 100 F, or up to 1650 F. This may be done by 1) improving properties of the nickel-and cobalt-base alloys, or 2) by providing molybdenum with protection against oxidation at elevated temperatures. Should this latter be achieved, molybdenum may find use at temperatures up to 2000 F.

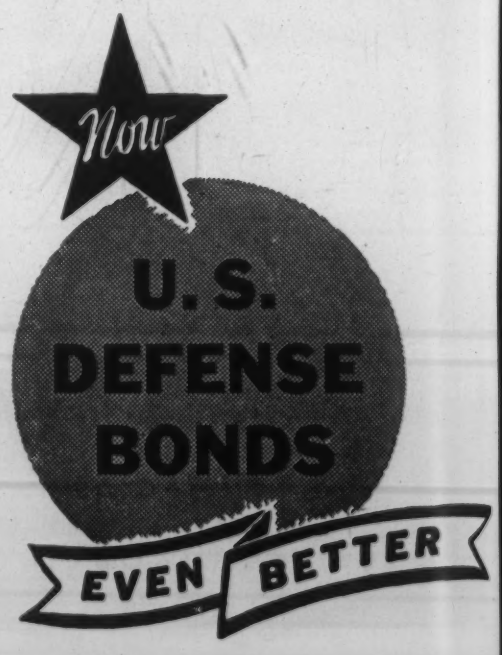
A third direction for research is in the ceramic and cermet materials. Although difficulties are still to be overcome, these materials may eventually prove the best solution to the problem.

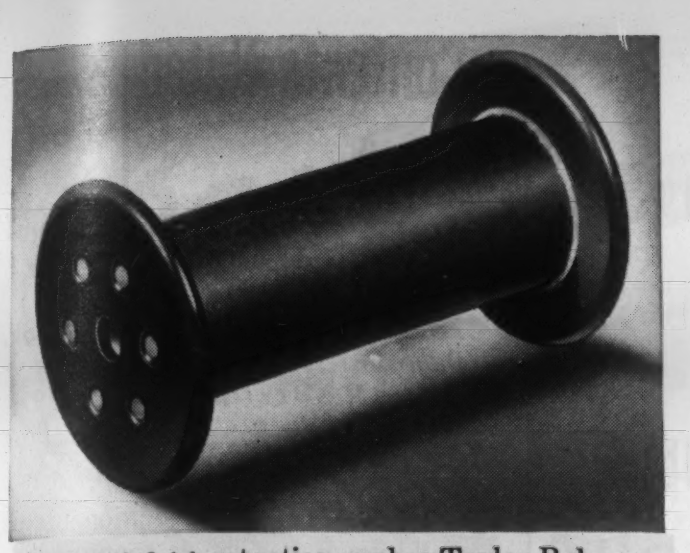
Why Ceramics?

Ceramic materials offer real promise because they have a high degree of corrosion resistance, and many of them far exceed most metals and metal alloys in high temperature resistance. According to one tabulation, 77 different ceramic materials have melting points ranging from 3000 to 7500 F. Further, they are relatively light, and generally in greater supply than are metals and metal alloys.

Their main drawback is brittleness which may cause brittle fracture under severe stress. There are two main approaches to the development of ceramics for use in turbojets. The first is to develop cermets, materials coupling the high temperature properties of ceramics with the stress and shock resistance of metals, and second, redesigning the power plant itself to reduce the stress and shock requirements for materials.

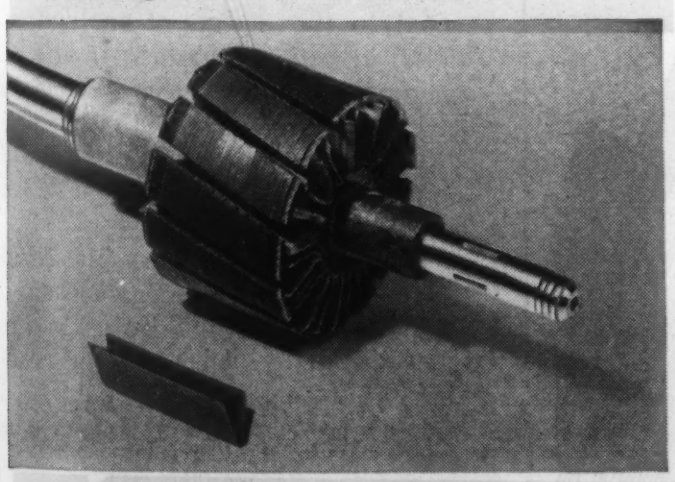
(Book Reviews on page 192)





Smooth finish retention makes Taylor Bobbin Fibre ideal for textile bobbins. High impact strength and easy machining add to its value.

Flexibility gives long life to abrasive discs backed with Taylor Vulcanized Fibre, which retains strength under repeated bendings.



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Contents Noted | Books

Plastics Engineering Handbook. *Published by Reinhold Publishing Corp., New York 22, N. Y., 1954. Cloth, 6½ by 9½ in. 813 pp. Price $15.00.*

This is the second edition of the well-known handbook sponsored by the Society of the Plastics Industry. However, it is practically a new book, since so much information has become available that the handbook has practically doubled in size. Over 200 specialists in the plastics industry have served on the 23 committees which have compiled this comprehensive treatment of the subject.

The handbook contains 20 chapters divided into five major sections. A major portion of the book is devoted to a discussion of materials and processes. In this section, chapters cover classification of rigid molding materials; molding; preforming, drying, and preheating; extrusion and extrusion machines; forming, drawing and postforming; reinforced plastics; casting; tooling with plastics; embedding; vinyl dispersions; and laminated products. A second section of four chapters is devoted to the design of molded articles, inserts and molds. In the remaining sections, three chapters cover finishing and assembly, there is a chapter on testing and one on SPI standards. An extensive index has been provided.

This book should be on the reference shelf of every engineer and designer whose work requires him to deal with plastics. It should be available to the supplier, fabricator and user of plastics for it provides a wide range of information on current processing, finishing and assembly techniques. The book would also be valuable for materials engineering students.

Induction and Dielectric Heating. *by J. Wesley Cable, Reinhold Publishing Corp., New York, N. Y., 1954. Cloth, 6 by 9 in. 620 pp. Price $12.50.*

This book has been written to give the practical man information on the applications of these two heating procedures. It contains only sufficient theory to furnish a background for the applications. The wide range of practical information

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A wide variety of Nickel alloys are also available for hundreds of electrical and mechanical applications. The excellent electrical characteristics of nickel are especially advantageous for electronic tube parts, such as grids, cathodes, support rods and pins. Monel, because of its excellent corrosion resistance and good mechanical properties, is also used for many mechanical parts, fasteners and springs.

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Contents Noted | Books

included will enable the engineer, designer and metallurgist to determine where induction and dielectric heating will fit into his program.

The book is divided into twenty-five chapters, twelve covering induction heating, the remainder dealing with dielectric heating. Each section begins with a discussion of the theory of the method and the operating principles of the equipment. Coil and electrode design are covered in sufficient detail to permit the user to design and build those necessary for any particular application. Subsequent chapters in each section cover applications in specific fields. These include forging, melting, brazing, hardening and other metal working applications of induction heating, and the application of dielectric heating in the plastics, woodworking and food processing industries.

Enamel Application by Dipping. *By Paul S. Cecil. Porcelain Enamel Institute, Inc., Washington 6, D. C., 1954. Paper, 6 by 9 in. 26 pp. Price $1.00.*

Prepared under the sponsorship of the Institute's Process Development Committee, the booklet is divided into three main sections. The first deals with General Application and considers four generally accepted methods of applying liquid porcelain enamel that come under the classification of dipping. The main section, Methods of Application, deals with equipment, enamel control, the recirculating dip tank, the temperature controlled dip tank and the humidity controlled area. Material Preparation, the third section, discusses the properties of the materials as they affect the draining properties of an enamel.

Bibliographic Survey of Corrosion. *National Association of Corrosion Engineers, Houston 2, Texas, 1954. Cloth, 8½ by 11 in. 346 pp. Price $12.50 to non-members NACE, $10.00, members NACE.*

Summaries of 3512 corrosion and corrosion prevention articles, books and brochures published in 1948-1949 are compiled in this volume. Abstracts by 30 technical societies were canvassed regularly for material taken from more than 500 sources.

Aluminum Data Book. *Prepared by B. E. Brennan and J. H. Pyles. Edited and produced by G. W. Birdsall. Reynolds Metals Co., Louisville, Ky.,*

(Continued on page 198)

Here, in this big picture-packed book, is an invaluable record of the year's best designing achievements and innovations

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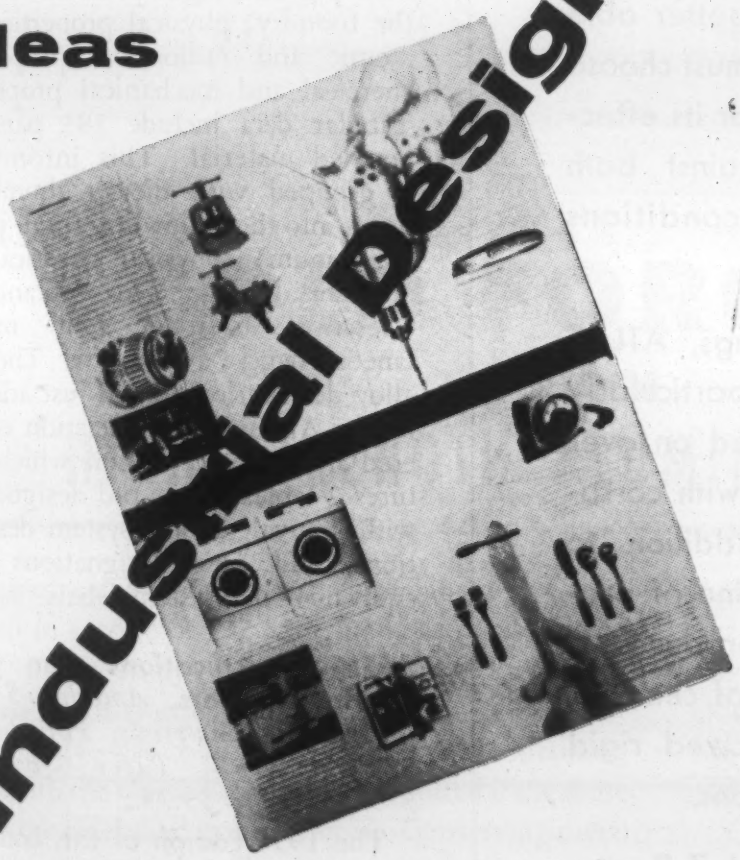

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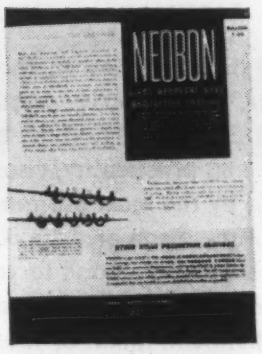

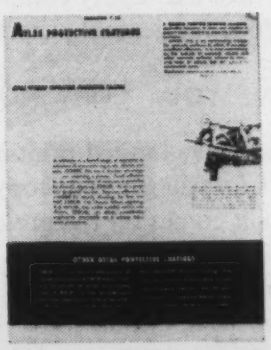

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Contents Noted | Books

1954. Paper 6 x 8 in. 220 pp. Without charge to technical men, executives and instructors upon request on company letterheads. $1.00 to all others.

Offering much information not to be found in previous issues, as well as a new die-cut thumb-indexing system, the 1954 edition of this volume makes readily available complete and detailed data on the properties and characteristics of aluminum. Included too, is a 20-page itemized cross index with references both to text and tabular information. The text covers wrought aluminum alloys, their nomenclature and heat treatment, 43 different aluminum mill products and their manufacture; fabrication; aluminum casting alloys including details on casting methods, foundry practices with definitions of seventeen aluminum pig and ingot products used in the foundry; physical properties and atomic and radioactive properties; chemical and mechanical properties. Tabular data include 183 pages of detailed material. This information is grouped with die-cut thumb indexes into the following: high purity (aluminum); physical, chemical and mechanical properties; (standard) tolerances; weights (and miscellaneous data); availability. The new alloy designation system just adopted by the Aluminum Association is covered in a special section which features 2 tables listing old designations with equivalent new system designations, and new designations with equivalent old system labels.

ASTM Specifications for Steel Piping Materials. *American Society for Testing Materials, Philadelphia 3, Penna., 1954. Paper, 6 by 9 in. 370 pp. Price $3.75.*

The 1954 edition of this compilation sponsored by ASTM Committee A-1 on Steel, contains in their latest form the 53 widely used ASTM specifications for carbon-steel and alloy-steel pipe and tubing, including stainless. In this special compilation, 22 of the specifications included in the previous edition have been revised, of this number 17 are tentative and 5 are standards. A new specification covers ferritic alloy steel forged and bored pipe for high temperature service. Ten emergency alternate provisions applying to these specifications are also included here. These emergency alternate provisions are issued by ASTM in accordance

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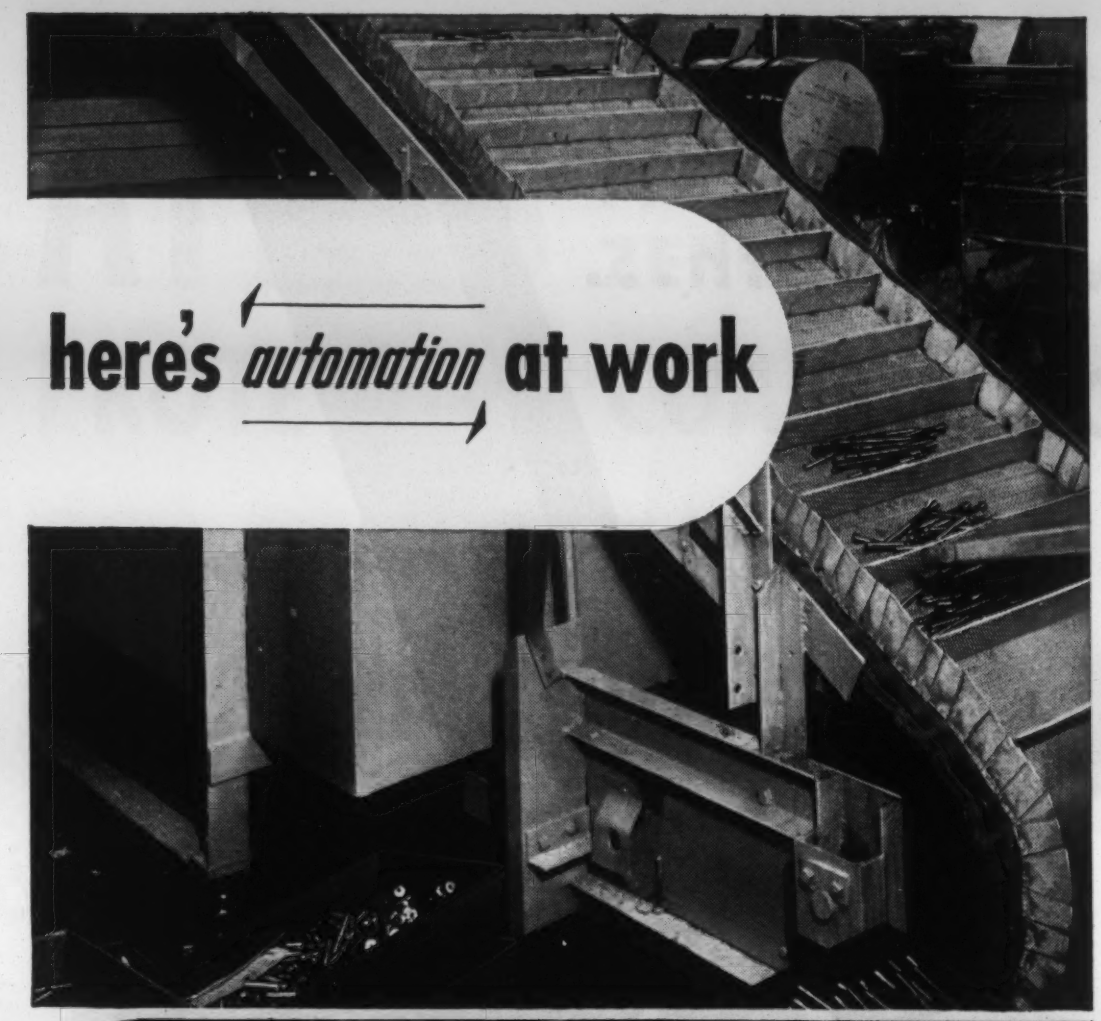

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Contents Noted | Books

with a special procedure in the interest of expediting procurement or conservation of materials during the period of national emergency.

ASTM Standards on Materials for Radio Tubes and Electronic Devices and Electrical-Heating, Resistance, and Related Alloys. *American Society for Testing Materials, Philadelphia 3, Penna., 1954. Paper, 6 by 9 in. 244 pp. Price $2.75.*

Prepared by ASTM Committee B-4, the 1954 edition of this compilation includes in their latest form, 44 widely used ASTM standards, including 30 test methods; 10 specifications; and four recommended practices. Materials and subjects cover: electrical-heating alloys, electrical-resistance alloys, electric-furnace alloys; radio tubes, electronic devices and lamps; heat resisting alloys; electrical contact materials; and thermostat metals.

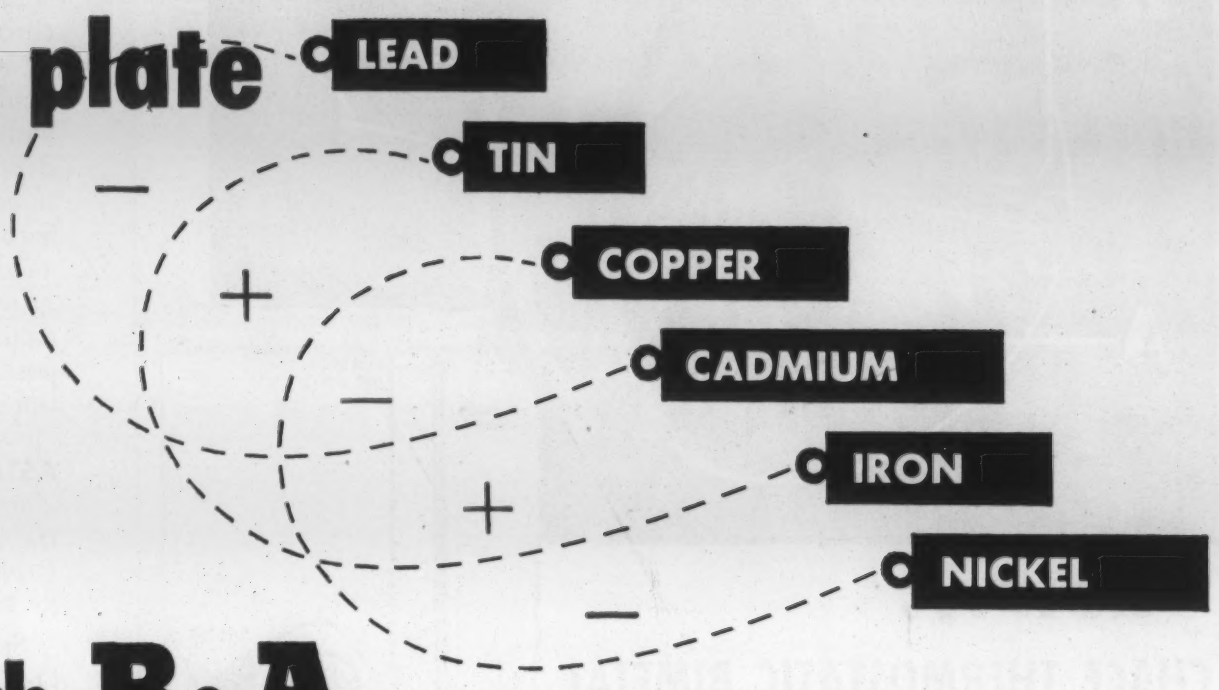
Tentative Specifications for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes. *Issued jointly by American Welding Society, New York 18, and American Society for Testing Materials. Philadelphia 3, Penna., 1954. Paper, 6 by 9 in. 10 pp. Price 25¢.*

For the first time, filler metal for inert-gas metal-arc welding aluminum has been standardized by the new specifications issued jointly by AWS and ASTM. These include aluminum and aluminum-alloy welding rods and bare electrodes. Twenty-two classifications of filler metal are established by these specifications. This includes all the commonly used aluminum and aluminum alloy filler metals. A table gives the chemical analysis of the different classifications. Standard sizes and length, packaging requirements and standard tests for verifying conformity of a given filler metal to the standard requirements are also provided. An appendix contains information on the use of each classification for joining different base metals with the different welding processes.

Chromium Plating. *By P. Morisset, J. W. Oswald, C. R. Draper, R. Pinner. Robert Draper Ltd., London, England, 1954. Cloth, 611 pp. Price $11.00.*

Designed to be of value to platers, chemists, managers, engineers and de-

These 10 Big Advantages Are Yours when you plate



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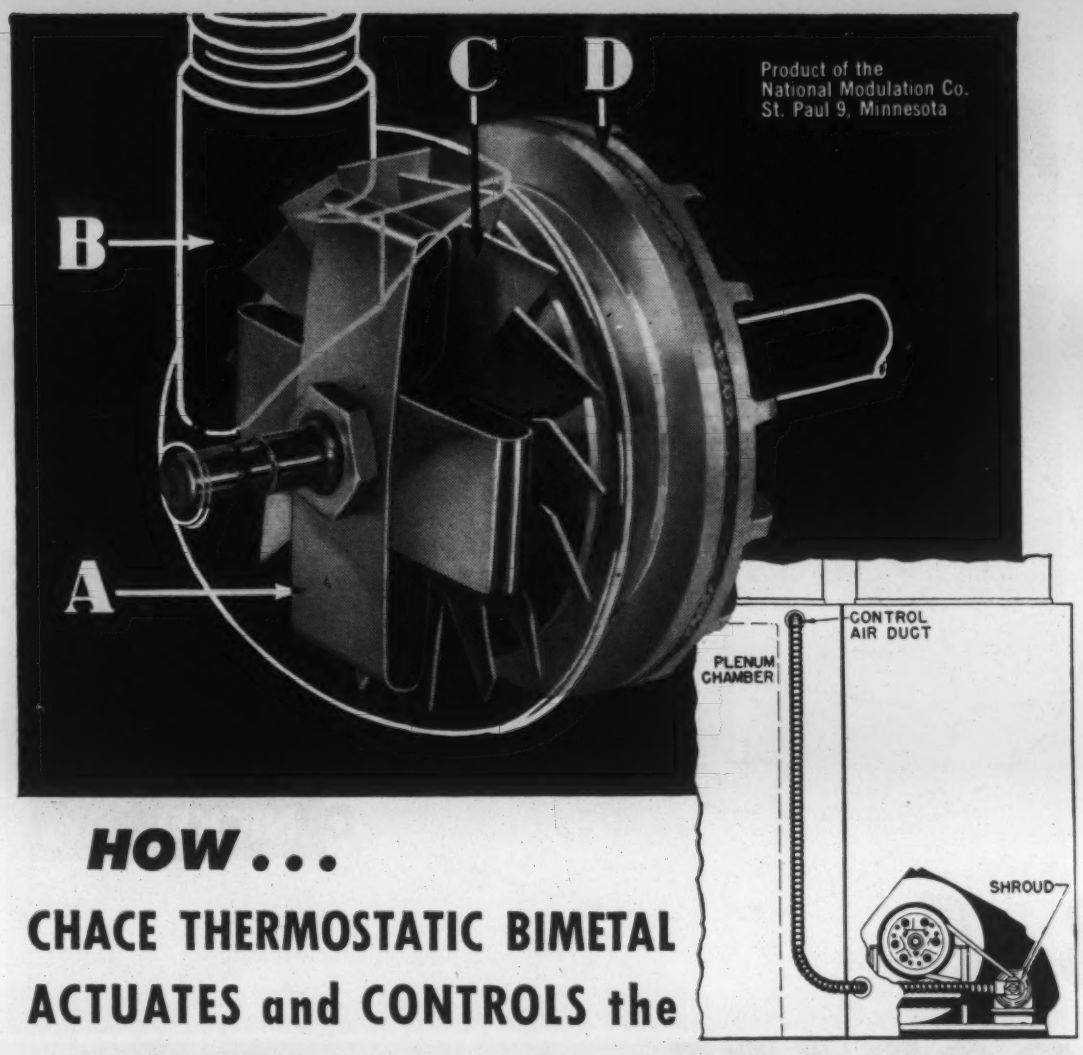

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Contents Noted | Books

signers concerned with parts to be chromium plated, this work discusses all significant developments in the field to the end of 1953. It deals with all types of chromium electrodeposits and all aspects of the chromium plating industry including hard chromium, decorative chromium, ancillary processes such as polishing, grinding, and machining of base metal, testing and inspection of deposits, control and analyses of solutions, etc.

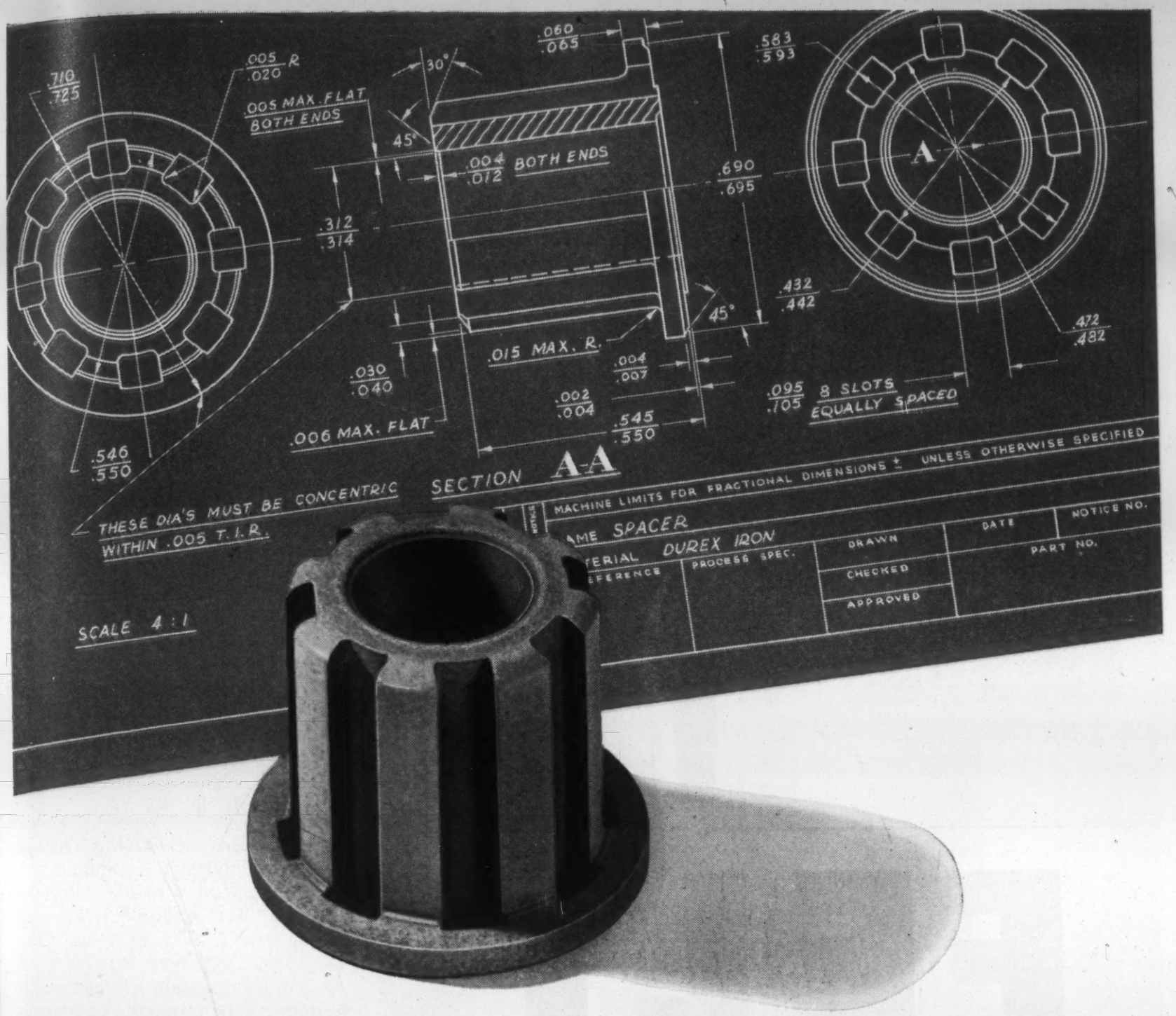
ASTM Standards on Plastics. *American Society for Testing Materials, Philadelphia 3, Penna., 1954. Paper, 6 by 9 in. 741 pp. Price $5.75.*

Sponsored by ASTM Committee D-20 on Plastics, this publication includes in their latest form, 142 ASTM standards, including 92 test methods, 32 specifications, 14 recommended practices, and 4 lists of definitions. New material includes specification and test methods for cellulose acetate sheet and film for primary insulation, nonrigid thermoplastic compounds for automotive and aeronautical applications, shrinkage of molded and laminated thermosetting plastics at elevated temperature, tension testing of vulcanized rubber, and measuring water vapor transmission of materials in sheet form. Standards cover properties (strength, hardness, thermal, optical and permanence), analytical methods, molds and molding processes, conditioning, plates, sheets, tubes, rods, and molded materials, and electrical tests.

Metal Industry Handbook & Directory, 1954. *Louis Cassier Co., Ltd., London, England, 1954. Paper, 6 by 9 in. 472 pp. Price $2.50. Also available with the weekly journal Metal Industry at a combined subscription rate of $8.00.*

Here is a comprehensive reference book for all those engaged in, or connected with, the nonferrous metal industry. It contains up-to-date information on the properties of the newer as well as the more familiar metals, and an extensive section devoted to summaries of current British Standards, Aircraft Material, D.T.D., and Admiralty Specifications. Also included is a section on the main metal finishing processes, and data regarding all the common rod, bar, sheet and strip products.

(Technical Reports on page 204)



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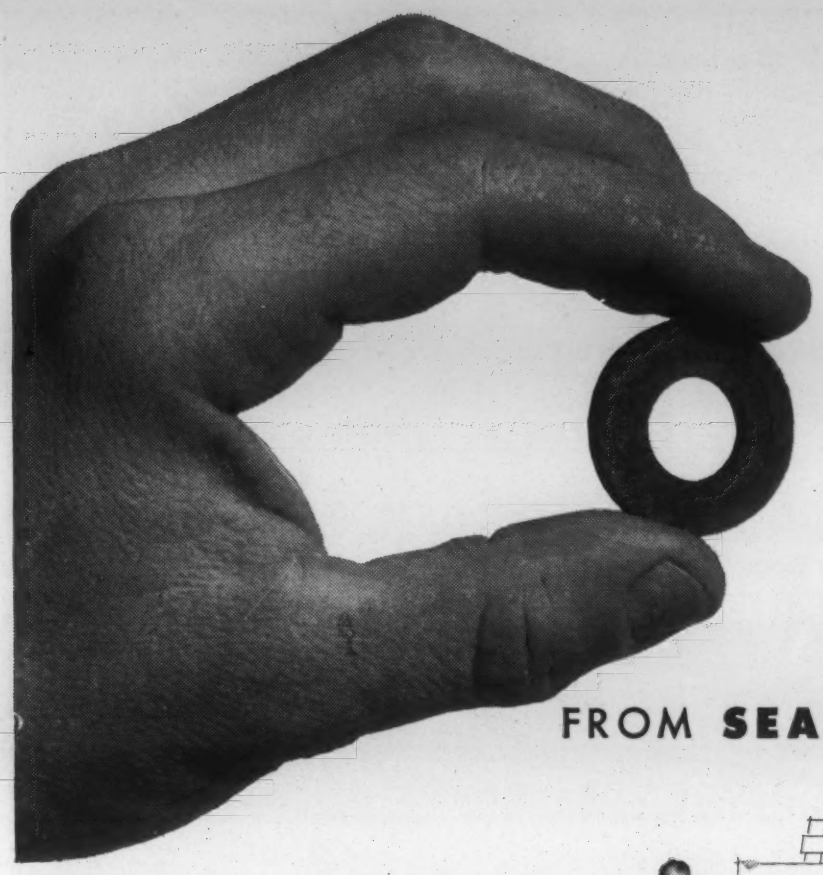

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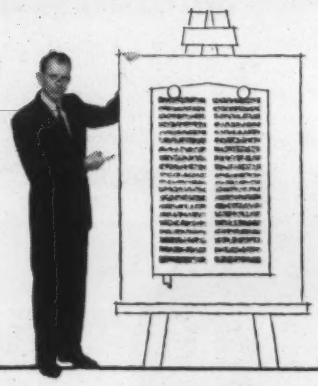

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Contents Noted | Reports

Declassified AEC Reports. The following reports have been selected from a bibliography of declassified and unclassified reports on research and development work sponsored by the Atomic Energy Commission. Copies of the reports can be obtained by writing to the addresses of the issuing installations given at the head of each group of reports.
Argonne National Laboratory
P.O. Box 299
Lemont, Ill.
Attn.: Dr. Hoylande D. Young

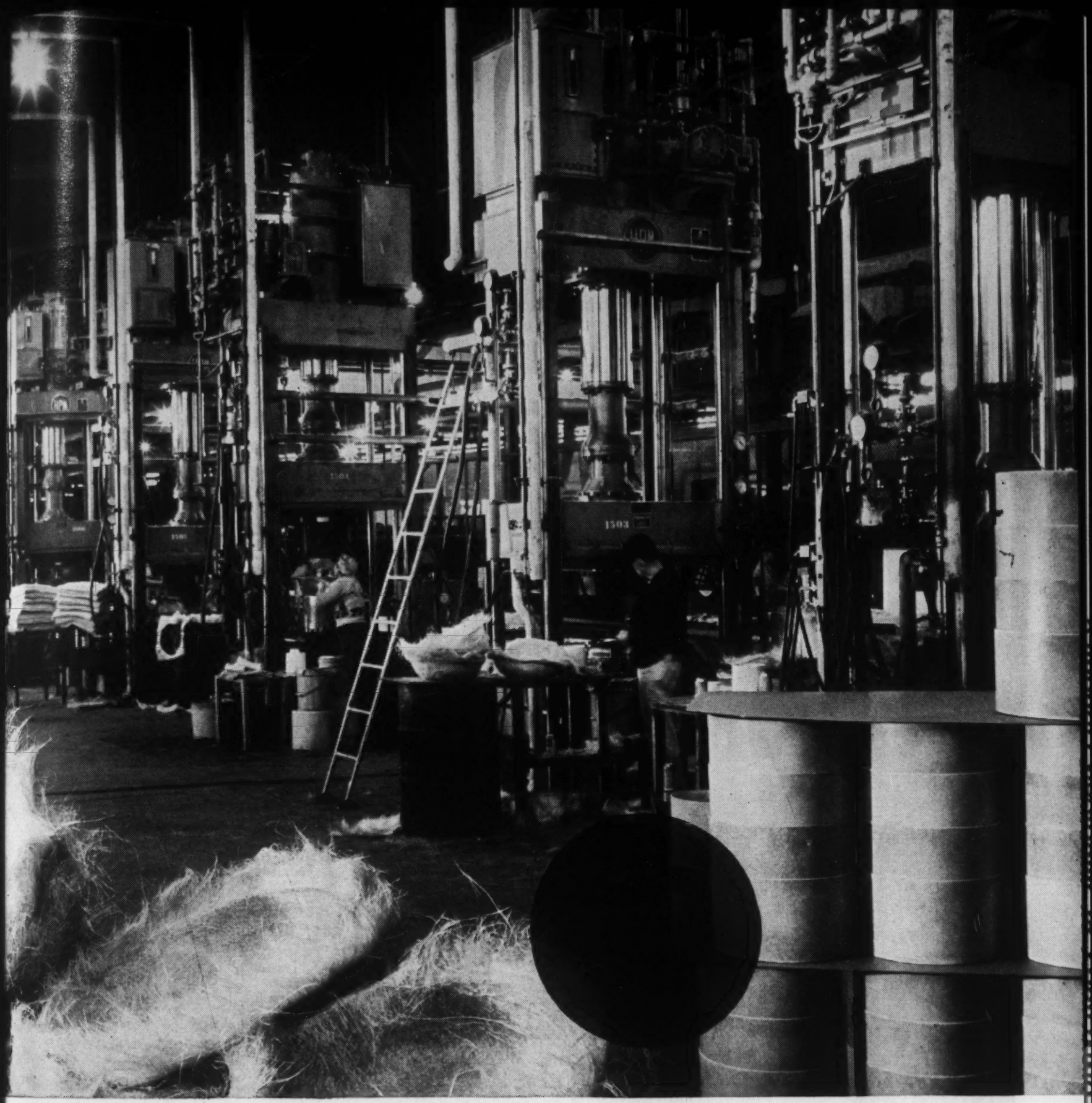
Molten Metal Attack. Resistance of Materials to Attack by Liquid Metals. *LeRoy R. Kelman, Walter D. Wilkinson, and Frank L. Yaggee. July 1950. 139 pp.* Tabular data and descriptive material are presented concerning the resistance of materials to attack by Na and Na-K alloys, Li, Hg, Pb, Bi, alloys of Pb and Bi, Mg, Cd, Tl, In, Ga, Al, Sn, Zn, and Sb.
Battelle Memorial Institute
505 King Ave
Columbus, Ohio
Attn.: Dr. H. W. Russell

Modification of Al-Mg Alloys. The Development of Aluminum—6% Magnesium Wrought Alloys for Elevated Temperature Service. *K. Grube and L. W. Eastwood. July 15, 1950,* Decl. *Nov. 10, 1950. 28 pp.* An investigation was undertaken to improve the properties of wrought Al-6% Mg alloys at 600 F. Although the 6% Mg binary alloy has very poor resistance to creep, it has been found that the addition of 0.5% Cr and approximately 0.10% Ti produces an alloy which, after stabilization at 600 F prior to test, has higher tensile properties at room temperature and at 600 F than 24S. Its resistance to creep at 600 F, 2500 psi load, is about equivalent to that of 24S Al alloy. In addition, the Al-6% Mg-0.5% Cr-O.10% Ti alloy has low density and probably good resistance to corrosion in ordinary environments.

Properties of a Ceramic. Aluminum Titanate as a Ceramic Material. *W. J. Koch and C. G. Harman. Nov. 20, 1950, Decl. July 30, 1951, 32 pp.* Experiments have been conducted to determine the properties of Al titanate, a compound containing equimolecular proportions of alumina (Al_2O_3) and titania (TiO_2). It has unusually low thermal-expansion coefficients, but bodies made of the equimolar compound are very weak

(Continued on page 208)

For more information, Circle No. 520



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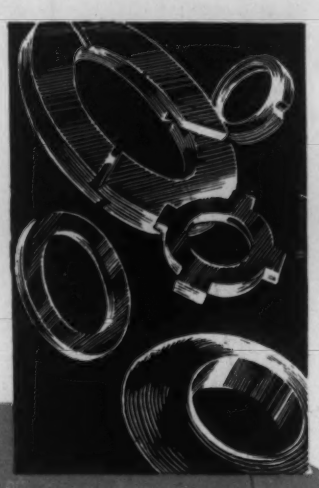

Late developments in Stackpole carbon-graphite shaft seals include oil seals that greatly minimize deterioration from pitting and blistering. Other types are designed for use with air, gases, corrosive chemicals and other liquids. Send details of your application for recommendation and samples.

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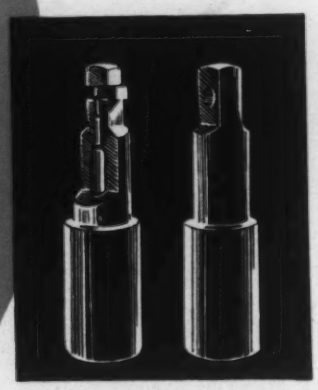
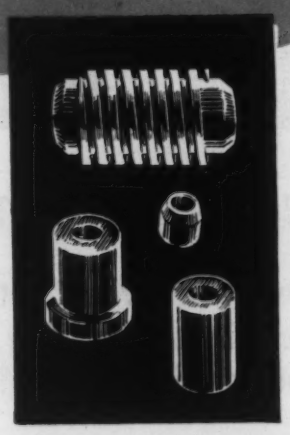


EASY SOLUTIONS TO MANY MOLD and DIE PROBLEMS



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Contents Noted | Reports

mechanically. The addition of an excess of Al_2O_3 increases the strength but also increases thermal expansion, while excess TiO_2 decreases both and increases fired shrinkage and porosity.

Tin Oxide Ceramics. Properties of Tin Oxide-Base Ceramics. *J. F. Quirk and C. G. Harman. Aug. 1, 1951, Decl. Nov. 9, 1951. 16 pp.* Various thermal and mechanical properties were measured for sintered tin oxide-matrix compacts which nominally were composed of 99 wt % of tin oxide, SnO_2, and 1 wt % of Zn oxide, ZnO. The tin oxide-matrix composition was similar in strength, at room temperature, to technical porcelains of the mullite or sillimanite type, but had far superior resistance to thermal shock and better strength at 1000 F. The tin oxide body might be expected to give good service under conditions of severe thermal shock and in an oxidizing atmosphere at temperatures up to 1500 F.

Beryllium. The Properties of Beryllium. *Murray C. Udy, Homer L. Shaw, and Francis W. Boulger. July 15, 1949, Decl. with deletions May 20, 1952, 154 pp.* A bibliography on the properties of Be is given. The physical, electrical, optical, magnetic, chemical, mechanical, and nuclear properties are briefly reviewed. The methods of purification and fabrication are also given.

Thermal Rupture of Ceramics. Effect of Shape and Material on the Thermal Rupture of Ceramics. *E. M. Baroody, W. H. Duckworth, E. M. Simone, and H. Z. Schofield. May 22, 1951, Decl. Jan. 21, 1953. 75 pp.* A preliminary investigation on the effect of shape and material on the thermal rupture of certain ceramics which appear to have promise as fuel-element materials, moderators or structural members for high temperature nuclear reactors is reported. The study deals primarily with thermal rupture caused by steady-state radial heat flow through a circular tube. Detailed equations for only the specialized cases of very short and of very long, round tubes are presented, and these are subject to certain restricted boundary conditions and assumptions.

Thorium Wire. Cold Drawing of Thorium Wire. *H. A. Saller, J. R. Keeler, R. J. Donley, and C. D. Graham. Oct. 10, 1951, Decl. with de-*

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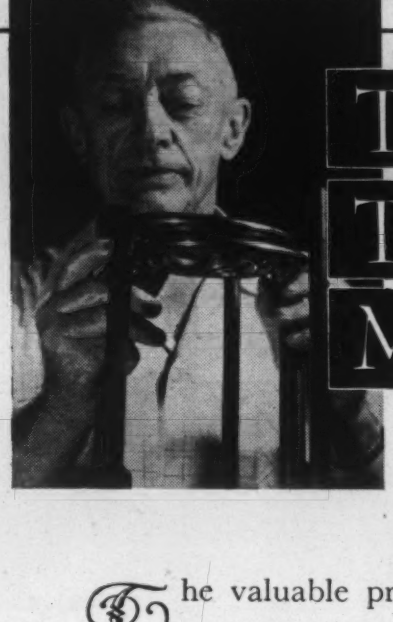

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Contents Noted

Reports

letions March 3, 1953. 12 pp. Various lubricants for cold drawing Th wire were investigated. The tendency for Th to seize in the die was overcome and Th wire was successfully drawn using a thinned lacquer suspension of MoS_2 and fumed Pb and Zn oxides as a lubricant. Th wire as small as 0.005 in. in diameter could also be drawn by enclosing the Th in a Cu jacket. The lacquer-base lubricant also permitted the successful drawing of Zr and Ti wire.

Silver-Cadmium Alloys. Thermal Conductivity of Silver-Cadmium Alloys from 100 C to 400 C. *H. W. Deem and H. R. Nelson. July 26, 1951. 11 pp.* Using the steady-heat-flow method, the thermal conductivities of a series of Ag-Cd alloys were measured over the range 100 to 400 C. Nominal compositions of the alloys varied from 5.4 to 35.7 wt % Cd. Mean thermal conductivities ranged from 0.61 cal /cm²/cm C/ sec for 5.4 wt % CD to 0.33 cal/cm²/cm C/sec for 36.7 wt % Cd.

Molybdenum. Welding of Molybdenum. *W. H. Kearns, H. B. Goodwin, D. C. Martin, and C. B. Voldrich. Sept. 1, 1951. 35 pp.* An investigation has been under way at Battelle Memorial Institute since 1949 to find the causes of brittleness in molybdenum welds and to find means of eliminating these causes. It was found that ductile upset welds can be made in high-purity molybdenum if contamination of the welds is prevented. Thorough cleaning of the faying surfaces prior to welding are necessary. Upset welds with some ductility can be made in commercial arc-cast molybdenum that is deoxidized with carbon. A postweld heat-treatment will produce some ductility in upset welds in commercial-swaged powder- metallurgy molybdenum, but porosity is a serious problem.

The Effect of Purification on Welds in Molybdenum. *W. H. Kearns, E. Eichen, D. C. Martin, and C. B. Voldrich. Dec. 1, 1952. 26 pp.* It has been found that the oxygen and nitrogen contents of commercial powder-metallurgy molybdenum can be lowered by heating it at 3500 F or above for several hours in a high vacuum. This solid-state-purified molybdenum is ductile at room temperature at a strain rate of 0.064 per second. Ductile upset welds can be made in purified molybdenum when welding is done

in high vacuum. Welds made in purified molybdenum in vacuum above one micron, dry tank hydrogen, or dry tank helium are brittle.

Introductory Plating Studies on Protecting Molybdenum from High-Temperature Oxidation. *L. E. Vaaler, C. A. Snavely, and C. L. Faust. Apr. 1, 1953. 20 pp.* Electrodeposited Ni protected Mo from air oxidation for 100 hr at 1800 F. The best samples lost only 0.1 to 0.2% of the original sample weight (about 3 g). Ni was deposited on Mo after various pretreatments: 1) a-c electrolysis in hydrofluoric acid; 2) a dip in alkaline ferricyanide solution; or 3) a combination of anodic cleaning in alkali, a dip in nitric acid, and a dip in alkaline ferricyanide. In most cases, a thin layer of Cr or Fe was deposited prior to Ni deposition. All deposits blistered when heated to 800 F in a vacuum (100 μ) except when Fe was deposited prior to the Ni. Ni, one mil thick, deposited directly on Mo or over a Cr plate, protected Mo for 100 hr at 1800 F, but Ni over Fe on Mo was not so effective. Attempts were unsuccessful to deposit Cu which would not blister on Mo when heated.

Silicon Carbide. A review of Silicon Carbide. *C. G. Harman and W. G. Mixer, Jr. June 3, 1952. 46 pp.* Information is compiled concerning silicon carbide and silicon carbide products, exclusive of abrasives. The information assembled here was selected from the published literature. A digest is presented of the chemical, physical, structural, and mechanical characteristics of silicon carbide. Data typifying the characteristics of refractories and refractory bodies based on silicon carbide are presented.

Joining Zirconium. Surface Preparation of Zirconium for Brazing. *W. C. Schickner, J. G. Beach, and C. L. Faust. July 1, 1952. 7 pp.* A method for applying a replacement Zn film on Zr and Zr alloy surfaces is described. Zn-coated Zr or Zr alloy can be soft soldered and silver soldered using conventional techniques.

Aluminum Alloys. Creep of 4S-O, J51S, and Number 22 Brazing-Sheet Aluminum Alloys at 300 F. *H. A. Saller, J. A. VanEcho, G. R. Remely, and J. T. Stacy. Jan. 9, 1953. 26 pp.* Creep-rupture tests were made on three aluminum-alloy sheet stocks, 4S-O, heat-treated J51S, and Number 22 brazing sheet, at 300 F in air. The

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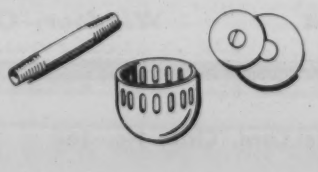

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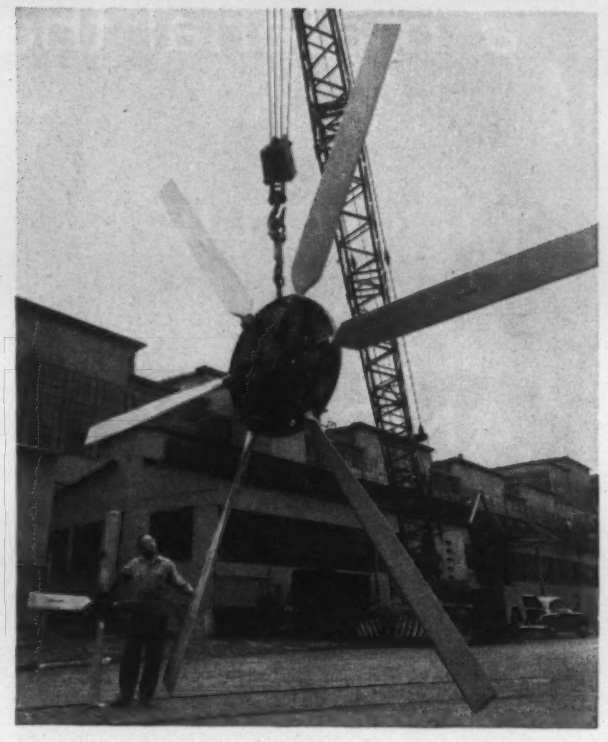

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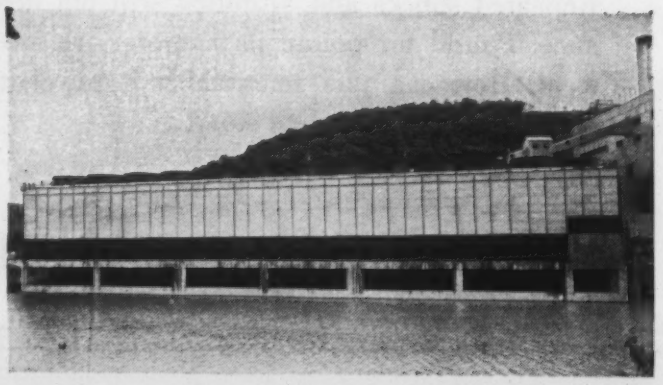

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Contents Noted | Reports

materials were tested in annealed condition, quenched and aged.

Work-Hardening Haynes Alloy. The Heat Treatment and Working of Haynes Alloy. *H. A. Blank, A. M. Hall, J. H. Jackson, J. W. Frank, and W. K. Anderson, Apr. 6, 1953. 31 pp.* Haynes 25 alloy can be machined when work-hardened to Rockwell C 48. Aging for 10 hr at temperatures between 1000 and 1300 F produces the maximum hardness. A hardness of Rockwell C 54 is obtainable in material previously cold-worked 40%. The surface hardness of material cold worked from 0 to 30% is increased by shot peening, but only to a depth of 0.002 in. Experimental melts were made in an attempt to improve the aging and machining characteristics of the alloy. The optimum hardness, after aging, for a given amount of cold work was obtained on Haynes 25 alloy modified by addition of 1 wt % Ti and 1 wt % Al. The hardness obtained on 30% cold-reduced and aged material was Rockwell C 54. Similarly treated Haynes 25 alloy specimens had a Rockwell C hardness of 50. Additions of S, Se, and Se in combination with Mo to the basic Haynes 25 alloy composition did not improve the machinability. Wear tests made on a variety of modified Haynes 25 alloy compositions in the cold-worked condition showed that this alloy is subject to galling. The alloy to which 2 wt % Ti and 0.2 wt % C had been added performed best among those tested. Perhaps next best was an alloy to which 0.10 wt % S and 0.12 wt % C had been added.

ML Aluminum Alloy Properties of ML Aluminum Alloy (Nominal Composition 4 copper, 2 nickel, 2 magnesium, 0.3 manganese, 0.3 chromium, 0.1 titanium, and 0.1% vanadium). *J. C. McGee, U. S. Air Material Command, Engineering Division, Materials Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, Dec. 1948. PB 111329, 50 pp, photographs, graphs, tables. Available from Office of Technical Services, U. S. Department of Commerce, Wash. 25, D. C. Mimeograph $1.00.* The effect of variations in chemical compositions from the nominal composition was studied by changing the proportion of one element at a time, and evaluating the tensile strength, microstructure, and other properties at 600 F. Report includes compositional limits derived.

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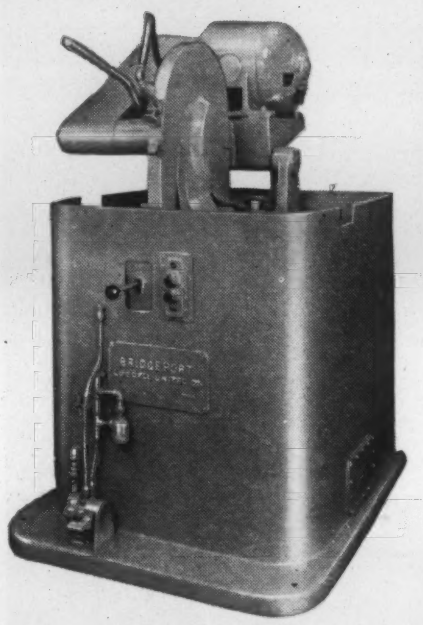

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news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

Dr. Fritz V. Lenel, specialist in powder metallurgy and **Dr. Ernest F. Nippes, Jr.,** director of welding research, have been advanced from associate to full professors by Rensselaer Polytechnic Institute.

•

Dr. John R. Dunning, nuclear scientist and Dean of Engineering, Columbia University, has been appointed to the technical and engineering committee of the Dow Chemical - Detroit Edison Atomic Power Project.

•

Alfred Sugar, division plant manager for the American Metal Co., Ltd., has been appointed vice president and technical director, Alloys & Chemicals Manufacturing Co.

•

Dr. Marcello L. Vidale has joined Arthur D. Little, Inc. as a member of the Operations Research staff.

•

Alfred Sonntag, manager of the Sonntag Scientific Corp., a division of Baldwin-Lima Hamilton Corp., has resigned his position to devote his time more exclusively to the Alpha Corp. of which he is president. Mr. Sonntag will continue in an engineering consultant capacity for Baldwin-Lima-Hamilton.

•

Dr. James F. Reagan has been appointed to head a new division of Beech Aircraft Corp.'s Engineering Dept. The division has been organized for the purpose of designing guided missiles and target aircraft.

•

Richard T. Coyne, former vice president of the Pressed Steel Car Co., has joined National Motor Bearing Co., Inc. as assistant to the president.

•

Dr. Joseph H. Paden has been named director of laboratories and **Dr. Mario Scalera** has been appointed director of research at American Cyanamid Co.'s Research Div.'s Bound Brook laboratories.

•

Walter E. Gregg has been appointed vice president and assistant general manager and **Dr. Walter L. Finlay** has been named vice presi-

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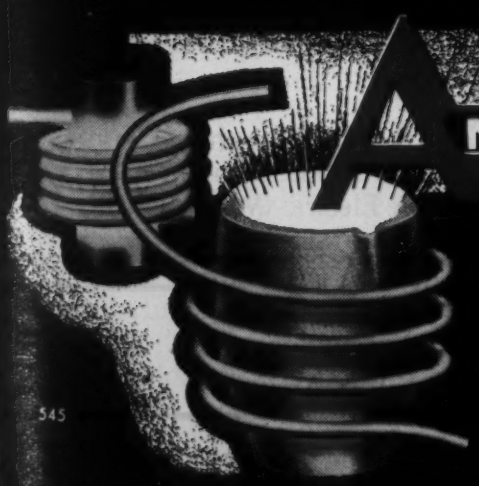

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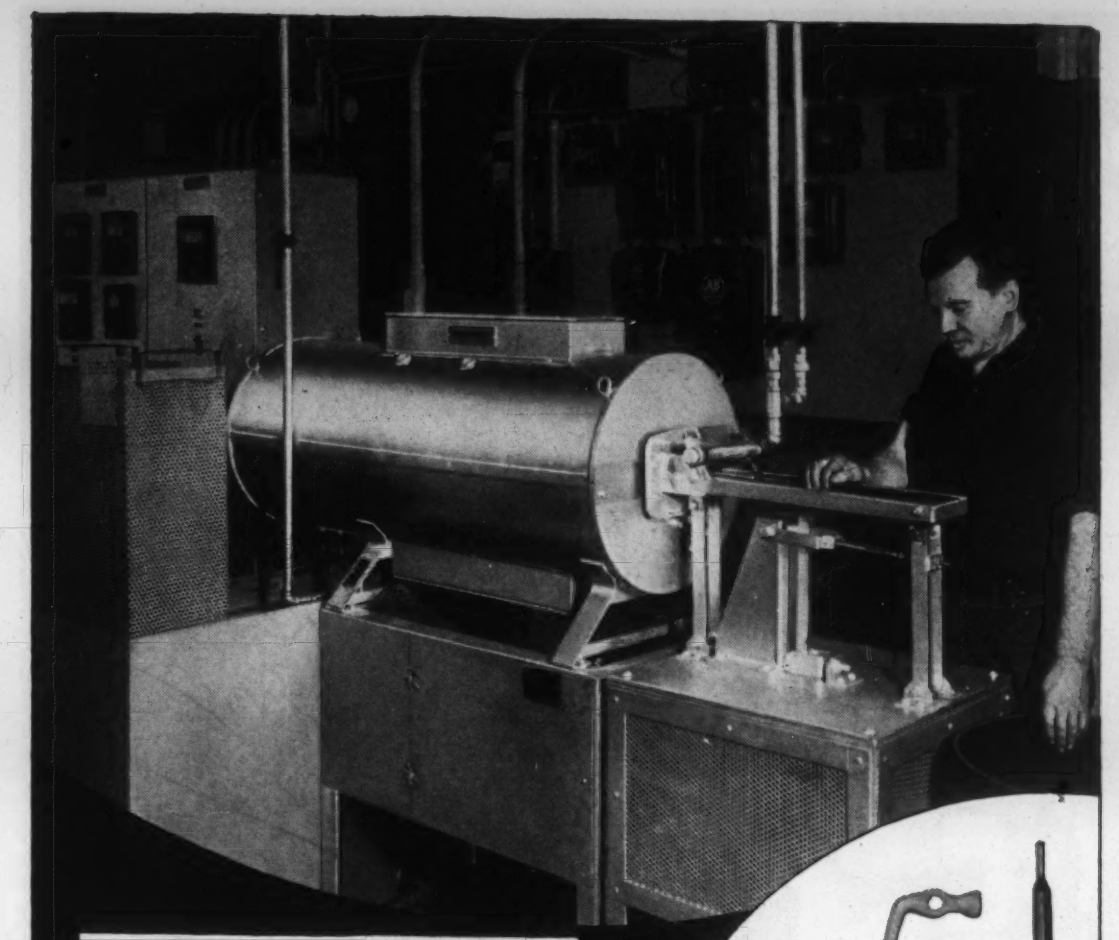

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news of ENGINEERS

dent and manager of research at Rem-Cru Titanium, Inc.

•

Herman L. Weckler has been elected general manager, Clevite Corp.

•

Dr. Robert P. Parker has been named to the newly created post of director of research of the Pearl River Laboratories, American Cyanamid Co.'s Research Div.

•

Fred H. Hehemann, chief engineer of the Lunkenheimer Co., is celebrating his 50th Anniversary with the company.

•

Ranald M. Garrison has been made manager of manufacturing, Hanson-Van Winkle-Munning Co.

•

Dr. Howard R. Spendelow, Jr. has been appointed assistant director of research in New York of the Metals Research Laboratories, Electro Metallurgical Co.

•

G. W. Hofstetter has been made manager of the Frit and Glaze Div., Ferro Corp.

•

Ralph L. Bayless has been appointed assistant chief engineer, research and development, Convair-San Diego.

•

Robert J. Ely has been named assistant chief metallurgist, American Brake Shoe Co.

•

Otto A. Keep has been appointed manager of control engineering; **Richard Lamborn** has been named manager of motor engineering and **Charles L. Reed, Jr.** has been appointed manager of engineering administration at General Electric Co.'s Locomotive and Car Equipment Dept.

•

Edwin H. Engel has joined Follansbee Steel Corp. as chief of quality control.

•

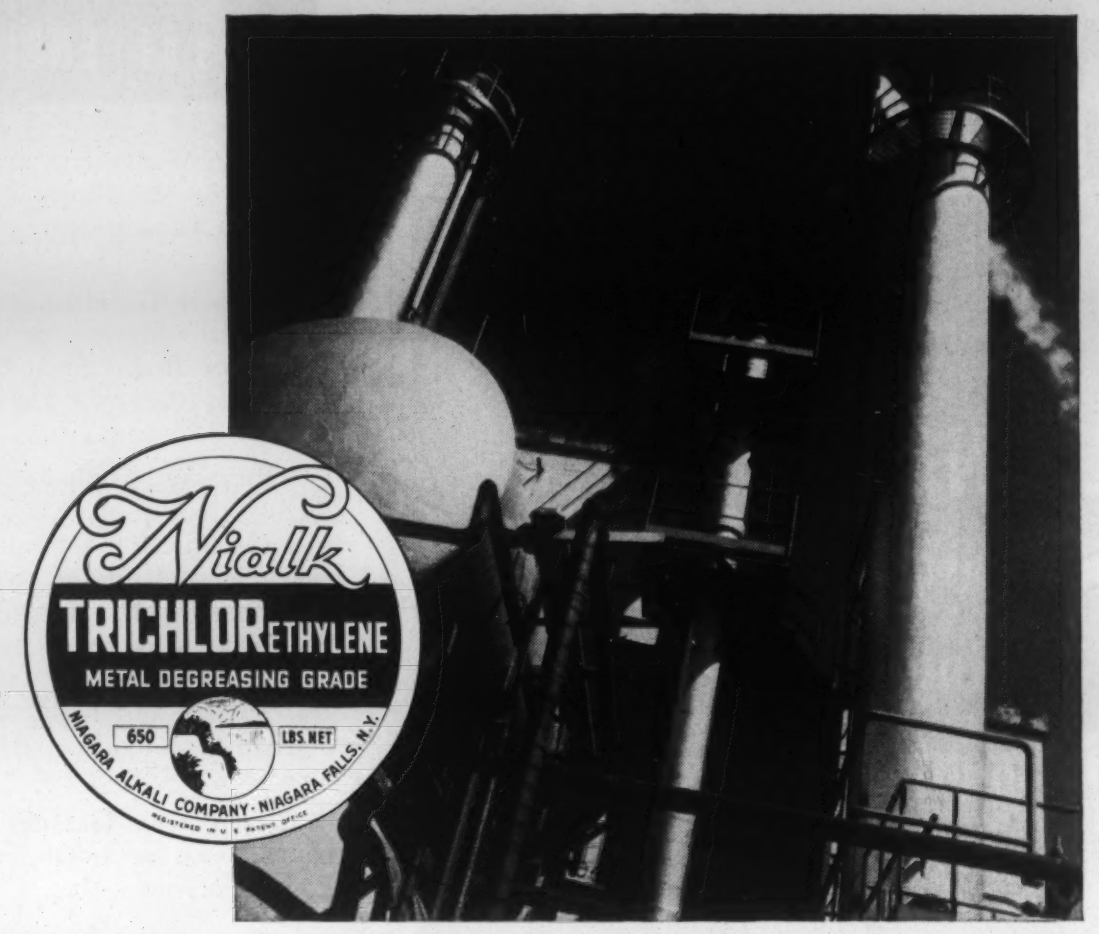
Albert Greenhaus, production and development engineer, has joined Berko Electric Manufacturing Corp.

•

I. Wendell Hamm has been appointed director of manufacturing for the Carborundum Co. Mr. Hamm was formerly chief of industrial engineering for duPont's Nylon Div.

•

William P. Evans, Raymond A. Foos, John P. Frenck, Robert A. Gustison, Robert S. Peterson and



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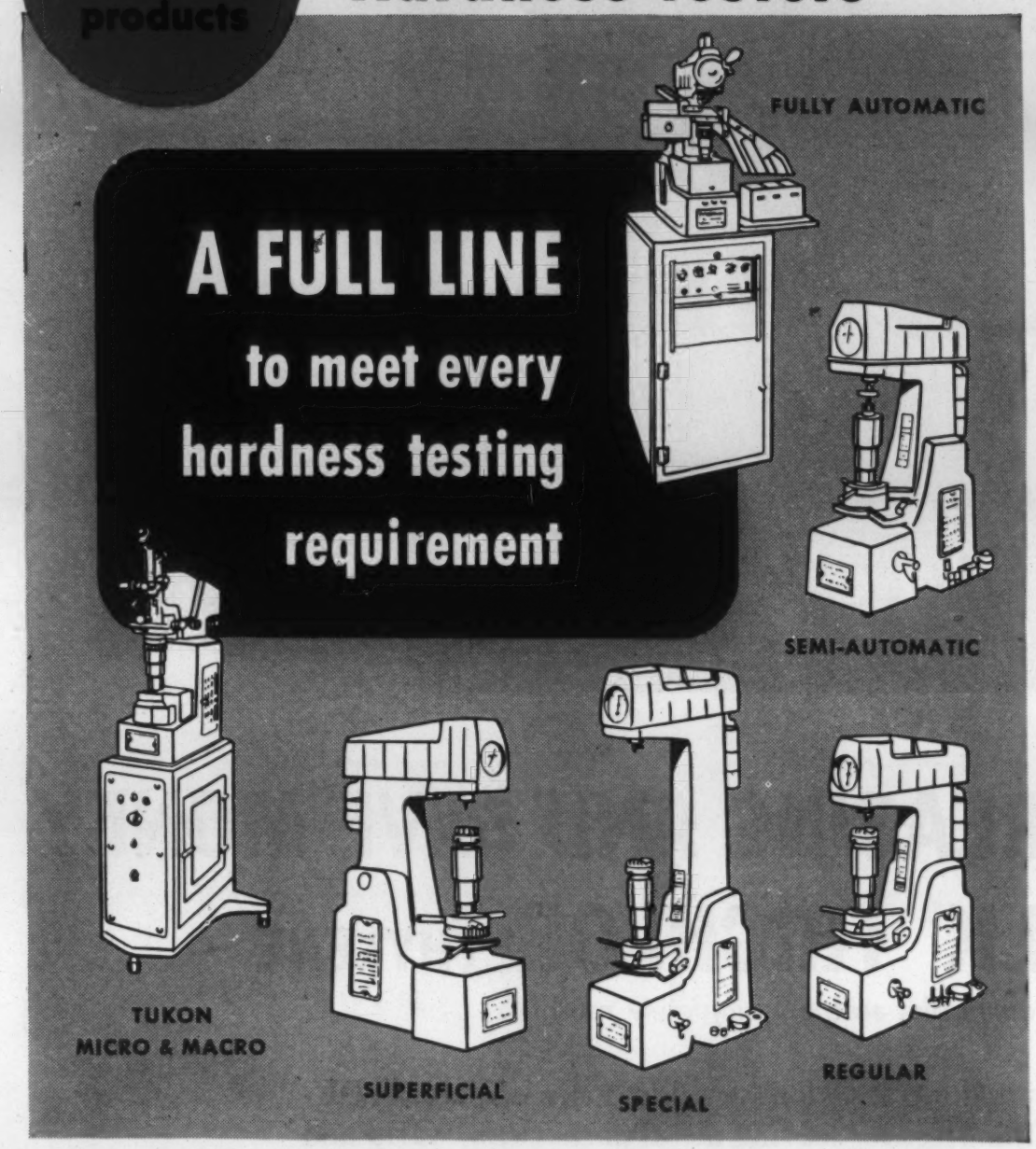

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news of ENGINEERS

James E. Wells have joined the staff of Electro Metallurgical Co.'s Metal Research Laboratories.

•

Howard B. Huntress has been appointed director of research of American Brake Shoe Co.'s newly-organized Sintermet Div.

•

Albert W. Cook has been named named chief project engineer, **Donald G. Smellie** appointed head of research and development section and **Charles F. Luginbill** placed in charge of all testing activities and laboratory operations within the aircraft wheel and brake development department, Goodyear Aircraft Corp.

•

Alfred A. Gassner has been named vice president, engineering, Lunn Laminates, Inc.

•

Carl G. Flygare, grinding development engineer at Norton Co., retired after 47 years with the company.

•

William E. Wade has been named technical director, Acme-Hamilton Manufacturing Corp.

•

John P. Termini has been appointed research engineer, the Permutit Co. Previously, Mr. Termini was employed by the United States Atomic Energy Commission in the Process Development Branch, Production Div., New York Operations Office.

•

Alfred B. Babcock, Jr., one-time assistant branch chief, New York Operations Office, AEC, has been named chief project engineer of Borden Co.'s Chemical Div.

•

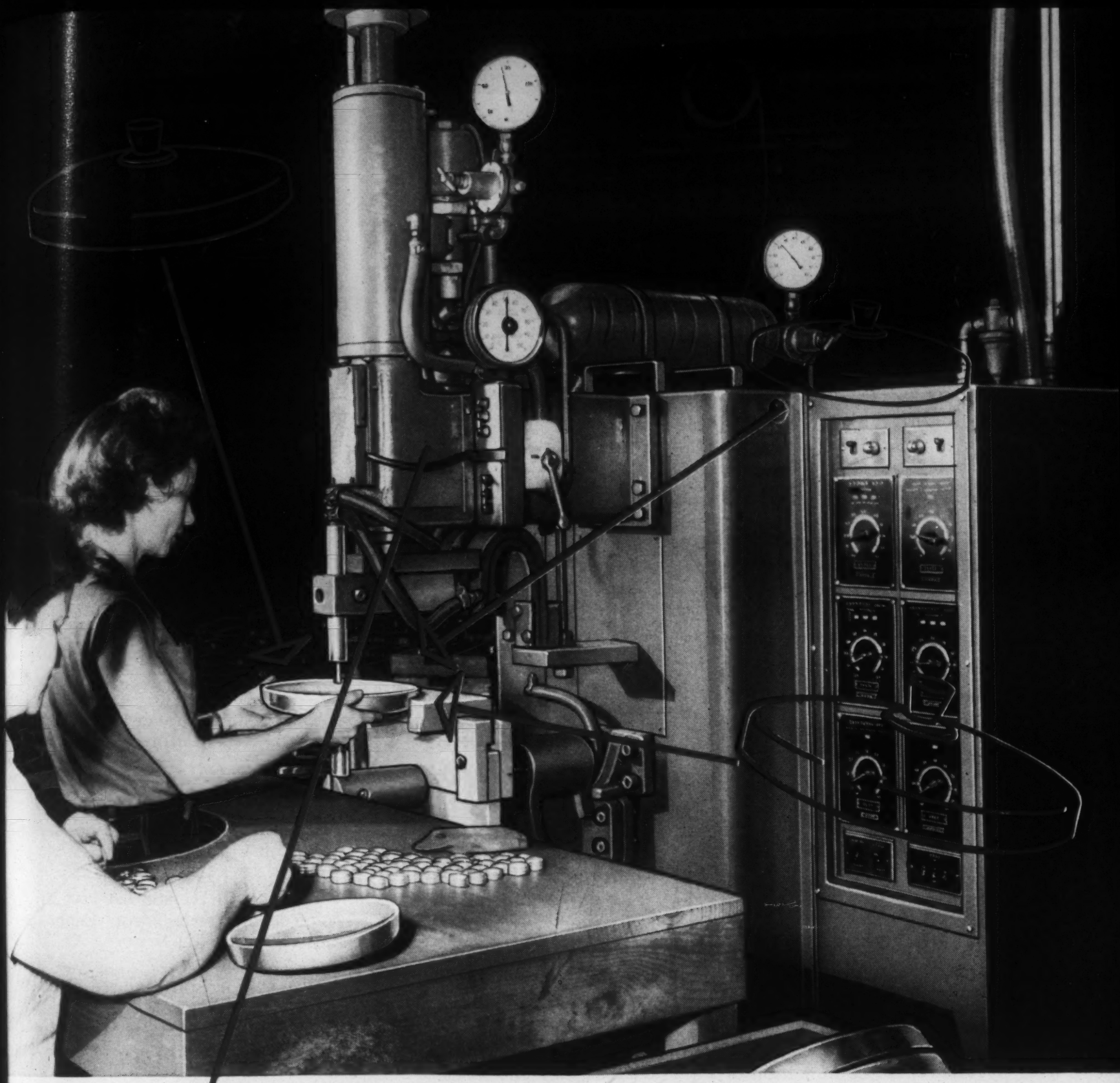
Albert Wiebe, former chief, Instrument Engineering Office, HQ Quartermaster Corps Inspection Service Command, U. S. Army has retired from that organization to assume direction of Albert Wiebe and Associates, Engineering Consultants with offices in New York City. **Alexander Koslow,** assistant chief of that office has been named Associate.

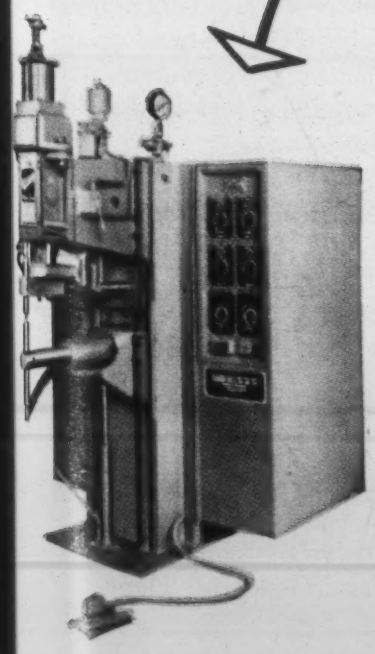
•

William M. Huston and **O. Bennett Schultz** have retired as consulting engineer and metallurgical engineer respectively from the Lima Works, Baldwin - Lima - Hamilton Corp.

(Continued on page 220)

For more information, Circle No. 497





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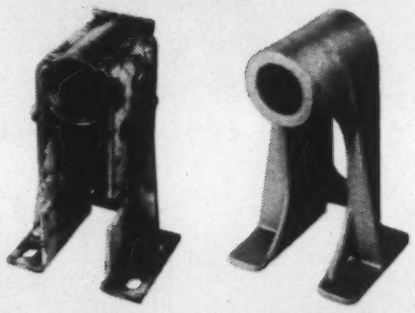

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news of ENGINEERS

Fred W. Emhardt has been appointed chief engineer, Struthers Wells Corp., Warren Div.

•

Walter E. Jones, metallurgical development engineer at the Thomson Laboratory, General Electric Co., has been appointed manager of vacuum melted products engineering at Carboloy Dept.

•

Col. H. F. Sykes, Jr. has assumed command of the main research center of the Corps of Engineers, the Engineer Research and Development Laboratories, Ft. Belvoir, Va.

•

E. T. Larsen has been named vice president - manager of engineering, and **Dr. W. C. Rueckel** has been appointed vice president-manager of development and sales, Henry J. Kaiser Co.

•

George E. Kempner has been appointed general manager, Welding Products Div., A. O. Smith Corp.

•

Paul H. Miller, research engineer, has joined the research and development staff of Wesson Co.

•

F. Kenneth Iverson has been appointed chief metallurgist, Cannon-Muskegon Corp.

•

W. D. Morrison has been named assistant to the director of the Development Dept., Celanese Corp. of America.

•

James B. Austin, Max W. Lightner and **Robert W. Holman** have been appointed assistant vice presidents, U. S. Steel Corp. Mr. Austin will be in charge of fundamental research; Mr. Lightner will head up applied research and development, and Mr. Holman will be responsible for operations research.

•

Thomas M. Bohen has been elected chairman of the board and chief officer of Whitehead Metal Products Co., Inc. **Clayton D. Grover,** vice president, succeeds Mr. Bohen as president.

•

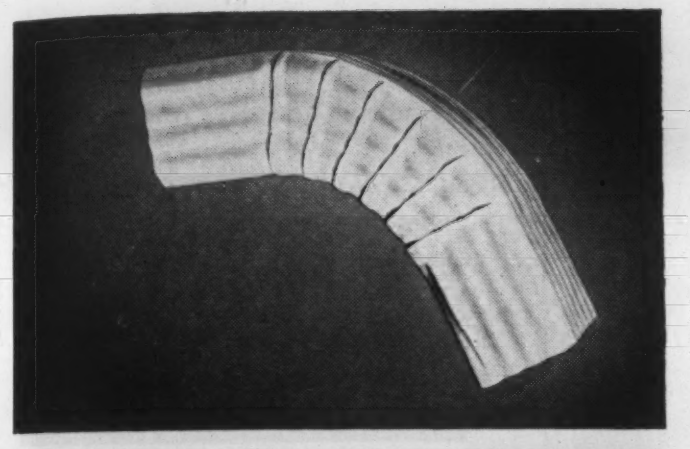
M. N. Halberg, formerly with the Industrial Engineering Section, General Electric Co., has been named application engineer of that company's Large Motor and Generator Dept.

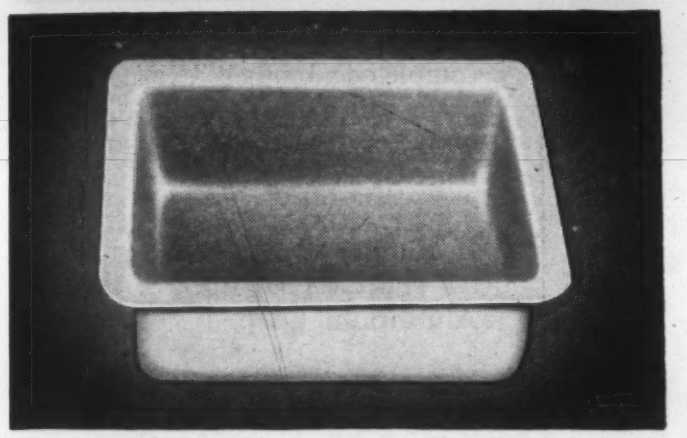
•

Robert H. Aborn, assistant director of United States Steel's Funda-

NEW Marvibond* PROCESS

Entirely new protection and beauty for sheet metal!





Marvibond is Naugatuck's revolutionary new process that bonds durable vinyl plastic sheeting to almost any type of metal—permanently—with advantages no other coating can match.

Revolutionary **Marvibond** *process...*

- **gives a protective coating many times more effective than conventional paint and lacquers.**
- **ends rust and corrosion—provides the unusual chemical resistance of vinyl compounds to acids, alkalies, salt water, alcohol, household chemicals, corrosive industrial liquids and atmosphere.**

Marvinol-Metal Laminates . . .

- **do not support combustion.**
- **have far greater abrasion resistance than galvanized steel, varnish, phenolic or alkyd finishes.**
- **will not chip, crack, craze or flake off.**

Applied before forming

By rolling and bonding vinyl sheet to the metal sheet *before* your product is formed, Marvibond process saves valuable production time and costly finishing operations. Marvibonded metal can be deep drawn, sheared, crimped, bent, embossed, drilled, and punched with standard tools—without damage *to coating or bond!*

New beauty, too

Marvibonded metal can be given a practically unlimited range of attractive, built-in colors, grains, and textures—beautiful and *lasting* decorative effects with other types of coating.

Any gauge metal or vinyl!

There are no particular restrictions on either the thickness of the vinyl used or the gauge of the metal. You get all the strength of metal needed, with the *outstanding* corrosion resistance of vinyl plastic.

Little difference what you make—there are money-saving, money-making uses for this exceptional new process practically everywhere. In machine housings, metal tiles, containers of all sorts, building panels, refrigerator liners, air conditioning systems — applications by the catalogue-full.

Better learn more about this new Marvibond process! Write on your letterhead to the address below. *Pat. Appl. For

50TH ANNIVERSARY 1904 1954 NAUGATUCK CHEMICAL

Naugatuck Chemical

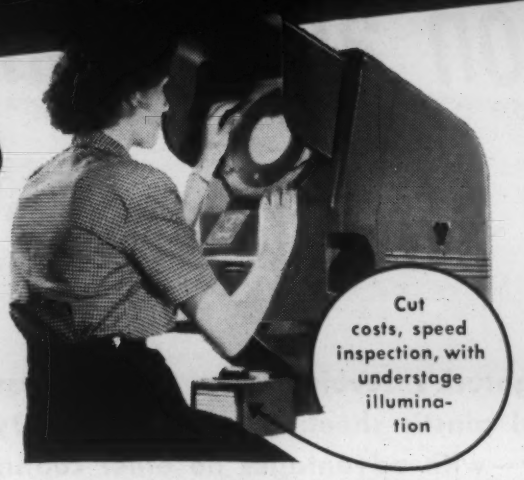
110 ELM STREET
NAUGATUCK
CONNECTICUT

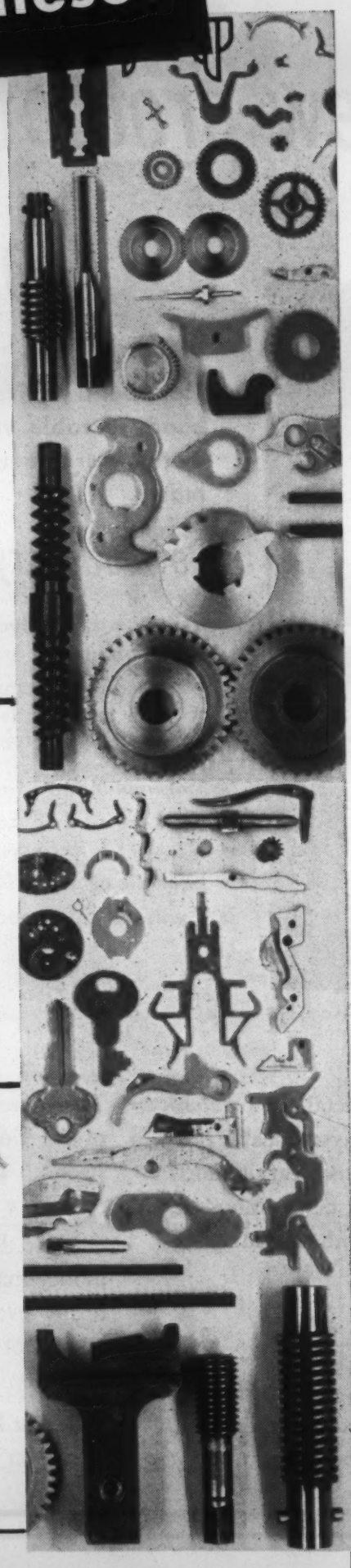
Division of United States Rubber Company

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis
New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario

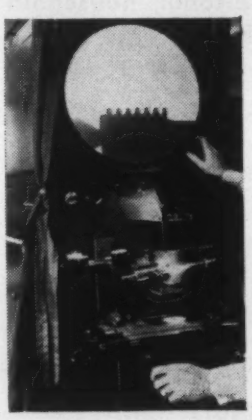
• For more information, turn to Reader Service Card, Circle No. 402

HOW you can meet close tolerances on parts like these!

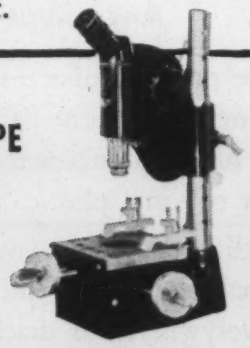




1 Bausch & Lomb BENCH COMPARATOR
Save every way! No costly holding fixtures needed for most work. No time-wasting set-up. Easy operation quickly provides vivid screen image, reveals costly production errors. Micrometer stage (optional) reads to .0001".



2 Bausch & Lomb CONTOUR MEASURING PROJECTOR
Quickly, easily shows sharp silhouettes or detailed surface views on 18" screen . . . for inspection, comparison, or highest precision measurements. Linear readings to .0001"; angular, to 1 minute of arc.



3 Bausch & Lomb TOOLMAKERS' MICROSCOPE
Quickly measures or inspects opaque or transparent objects of any contour. Linear readings to .0001"; angular, to 1 minute of arc.

SOLD AND DISTRIBUTED EXCLUSIVELY BY THE DoALL COMPANY For full information call your local DoALL Sales-Service Store, or write: The DoALL Company, 254 N. Laurel, Des Plaines, Illinois.

BAUSCH & LOMB
SINCE B&L 1853

Quality Control
INSTRUMENTS

news of | ENGINEERS

mental Research Laboratory, has been named director of the laboratory.

•

L. C. Schweitzer has been appointed assistant general manager of the TOCCO Div., the Ohio Crankshaft Co.

•

Richard A. Humphrey has been named chief—research and development of Mycalex Corp.'s Clifton plant.

•

Virgil C. Rice has been appointed director of manufacturing, Norge Div., Borg-Warner Corp.

•

Robert E. W. Harrison has been appointed director of special engineering projects, Sintercast Corp. of America.

news of | COMPANIES

The **R. C. Mahon Co.** has just completed another expansion program which adds some 130,000 sq ft of factory space and 20,000 sq ft of office space.

•

Mueller Brass Co. has acquired the entire capital stock of the **Sheet Aluminum Corp.**

•

B. F. Goodrich Co. has announced purchase of the **Sponge Rubber Products Co.** Hereafter the Sponge Rubber Products Co. will be known as B. F. Goodrich Sponge Products Div., B. F. Goodrich Co.

•

Otto H. York Co., Inc. and **York Process Equipment Corp.** announce the relocation of their offices and plants to new, larger quarters at 6 Central Ave., W. Orange, N. J.

•

Salem-Brosius, Inc. and **Phillips Corp.**, while completely maintaining their separate corporate identities, have agreed to pool production facilities.

•

Lunn Laminates, Inc. has announced a million-dollar expansion program scheduled for completion early in 1955.

•

General Electric Co. has formed an Atomic Power Equipment Component which will market atomic power equipment for commercial use.

(Continued on page 224)

HEAT TREATING WITH

SPENCER HARTFORD TURBOS

Surface Combustion manufacturers heating and heat treating equipment for both direct firing and controlled atmosphere.

by the

SURFACE COMBUSTION CORP.

For a quarter of a Century Spencer Turbos have been preferred equipment for the many types of Surface Combustion heat treating equipment.

Here are some of the reasons:

1. Constant pressures maintained regardless of load.
2. Simple—sturdy construction. Operates with low maintenance for a life time.
3. Wide clearances. Only two bearings to lubricate.
4. Unusually quiet. Practically no vibration.
5. Standard designs meet all requirements—single and multi-stage—35 to 20,000 cu. ft.; ⅓ to 600 Hp.; 8 oz. to 10 lbs.

Ask for Technical Bulletin 126 and the Turbo Data Book No. 107.

SEE SPENCER IN THE A.G.A. SECTION AT THE METAL SHOW

THE SPENCER TURBINE COMPANY

SPENCER HARTFORD

HARTFORD 6
CONNECTICUT

494-B

Manufacturers of Turbo-Compressors and Heavy Duty Vacuum Cleaners

For more information, turn to Reader Service Card, Circle No. 353

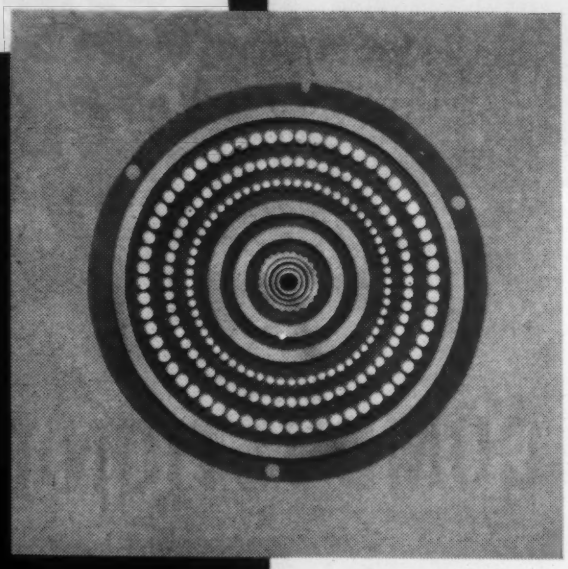
MYCALEX

Announces...

Substantial Price Reductions

on

Mycalex 410 Telemetering Commutator Plates



Increased production of Mycalex 410 Telemetering Commutators now brings new savings to the user. Universally accepted as the finest commutator plate in the field, this precision-built unit injection-molded of Mycalex 410 glass-bonded mica insulation assures permanent dimensional stability – provides a tenacious bond to the metal inserts.

Important MYCALEX features–

- no dimensional change with age, humidity or temperature
- contact flatness within .0002"
- permanently high inter-contact dielectric strength
- repeated solderability – no loose contacts under vibration or shock
- high speed brush means no "bounce", no "hash", provides square wave switching.

MYCALEX ELECTRONICS CORPORATION

Under exclusive license of Mycalex Corporation of America

Executive Offices:
30 Rockefeller Plaza,
New York 20, N. Y.

Address Inquiries to General Offices and Plant:
Dept. 124
Clifton Boulevard
Clifton, N. J.

Revised price lists are available now. Write for your copy today.

SINCE 1919 MYCALEX THE INSULATOR

news of | COMPANIES

Knapp Mills, Inc., and **Aug. Schnackenberg & Co.**, Germany's leading producer of lead chemical equipment, have concluded an 18-year license agreement whereby the German firm employs Knapp's patented processes for the production of lead clad metals in Germany.

•

Carboloy Dept., General Electric Co., recently opened a new laboratory for measuring and analyzing magnetic materials.

•

Vanadium-Alloys Steel Co. has completed the first phase of a program designed to modernize its rolling mill facilities with the installation of a new 12-in. merchant bar rolling mill.

•

Monsanto Chemical Co.'s Inorganic Chemicals Div. will have a new research center at Creve Coeur, Mo. completed by the fall of 1955.

•

Damascus Tube Co. and **Swan Engineering Co.** have consolidated to provide greatly expanded services.

•

Empire Steel Castings, Inc. has recently completed an $800,000 expansion and modernization program.

•

Enamelstrip Corp., recently held ground breaking ceremonies for an ultramodern $300,000 addition to plant.

•

Salkover Metal Processing of Illinois, Inc., has moved to its new plant at 2550 Edgington Ave., Franklin Park, Ill.

•

Whitehead Metal Products Co. is now distributing non-metal pipe and fittings made of rigid vinyl plastic by **Alpha Plastics, Inc.**

•

Westinghouse Electric Corp. recently opened its new plant in Montevallo, Ala. for the manufacture of welding electrodes and brazing rods.

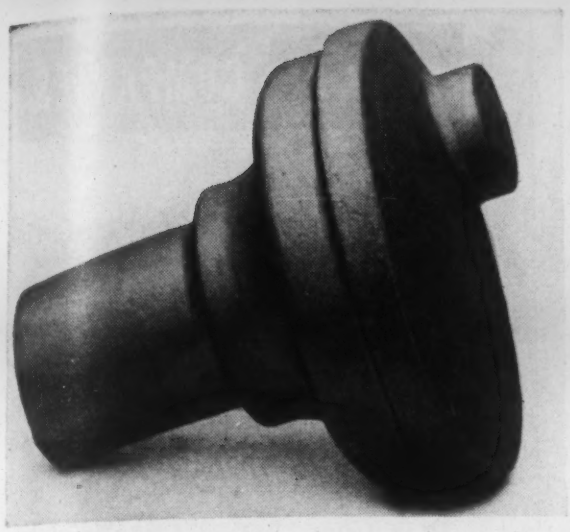
•

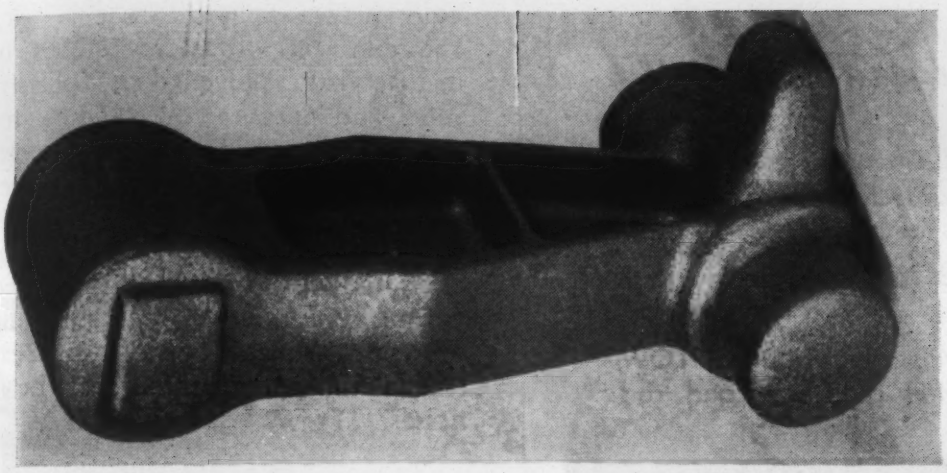
R & S Tool Co. has completed its move to new, enlarged quarters at 13100 Enterprise Ave., Cleveland 11.

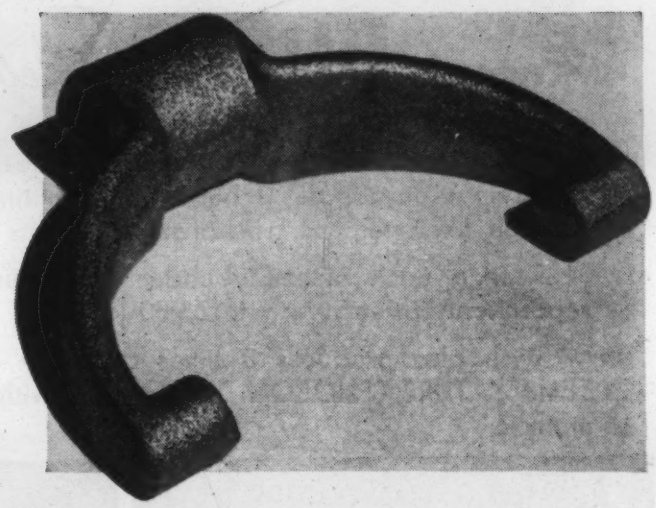
•

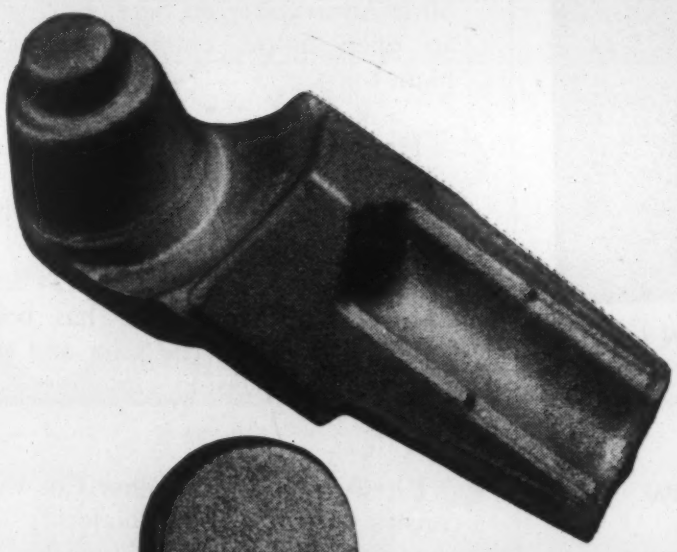
General Chemical Div.'s Research Laboratory is now located on Columbia Rd. near Park Ave., Morristown, N. J. All future communications should be addressed to: General Chemical Research Laboratory, General Chemical Div. Allied Chemical

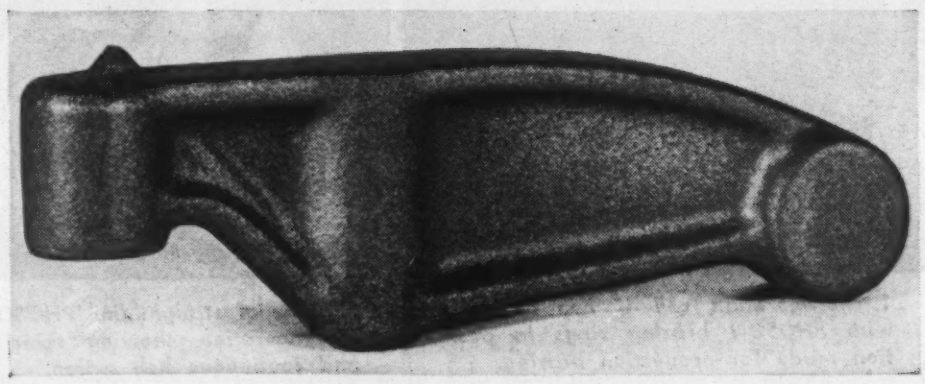
For more information, turn to Reader Service Card, Circle No. 459











From Bethlehem's Showcase of DROP FORGINGS

In our Bethlehem drop forge shop we have a big display board showing hundreds of the designs we have made in recent years.

The eight forgings shown here were chosen from the board to illustrate, in a small way, some of the sizes and types that Bethlehem can handle. We're equipped to make closed-die forgings ranging in weight from a few ounces to more than 200 lb—and the variety of designs is practically unlimited.

Bethlehem's drop forge division is a completely-integrated operation, embracing every step from the making of the steel to the cleaning, inspection, and shipping of the finished forgings. Our facilities include an up-to-the-minute die shop, steam and board drop hammers to 8000 lb, mechanical presses to 3000 tons, and all necessary heat-treating units.

Why not talk business with us the next time you're in the market? We're able to make you as fine a drop forging as it's possible to buy, in either carbon or alloy steel. Check with us, won't you? We think you'll like our service.

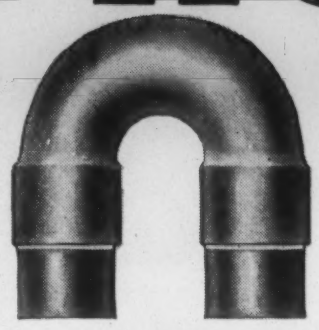
BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

For more information, turn to Reader Service Card, Circle No. 437

7,980 PHOSON BRAZED JOINTS



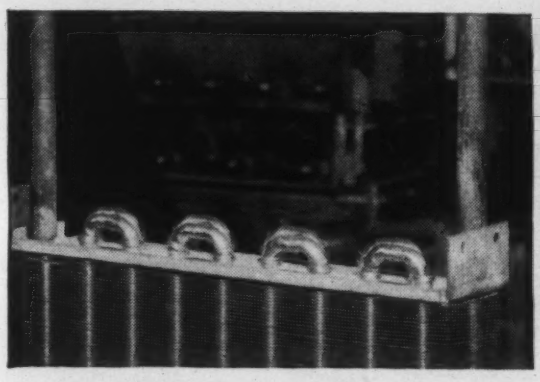
3 REJECTS!

Reports BUSH *on Refrigeration Coil!*

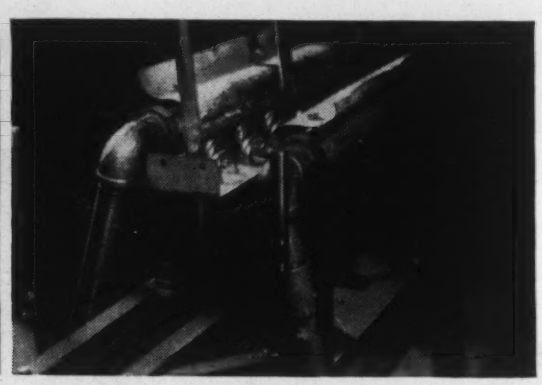
Bush Manufacturing Company, Hartford, Connecticut brazes 24 alloy rings on copper U bends in a continuous chain belt operation through fixed torches. The brazing process is automatic.

Testing each assembly under 300 pounds of air pressure, Bush reports only *three rejects* in 7,980 joints.

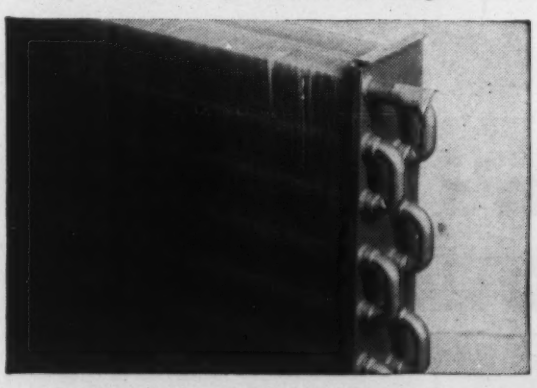
Bush also produces 8 times as many units the STRONG, LOW TEMPERATURE, PHOSON WAY, than with the old torch and rod method.



1. Refrigeration coil U bends shown with PHOSON brazing rings in position ready for production brazing.



2. View of straight line PHOSON brazing operation showing fixed torches and continuous belt action.



3. This is the finished PHOSON brazed refrigeration coil. No further machining or polishing needed . . . a clean, smooth job every time.

GET DEPENDABLE, LOW COST PHOSON IN STRAIGHT LENGTHS, COILS OR PREFORMED RINGS.
Ask for NEW
PHOSON BOOKLET

DEPENDABLE United WIRE BRAZING ALLOYS

NEW PHOSON PERFORMANCE TELLS THE STORY!

CONTACT YOUR NEAREST UNITED WELDING SUPPLY DISTRIBUTOR
Complete distributor list on request

See New Color, Sound Movie
"WHEN METALS ARE BRAZED"
Write United Wire for showing date in your city!

UNITED WIRE
AND SUPPLY CORP.
Brazing Alloy Division
PROVIDENCE 7, R. I.
OFFICES IN PRINCIPAL CITIES

For more information, turn to Reader Service Card, Circle No. 472

news of | COMPANIES

& Dye Corp., P. O. Box 405, Morristown, N. J.

•

International Telephone and Telegraph Corp. has formed a new domestic research and manufacturing division, the Farnsworth Electronics Co. at Fort Wayne, Ind.

•

Plax Corp. has sold to **Westlake Plastics Co.** its entire production equipment, applicable patents, etc., for extruding rods and tubes of methacrylate, polyethylene, polystyrene, and fluorocarbon (Kel-F) for molding heavy gage sheets of polyethylene and polystyrene and all gages of fluorocarbon. The Plax management has sold this part of its operations to provide needed space and permit concentration on its rapidly growing "squeeze-bottle" and extruded film and oriented sheet businesses.

•

Pangborn Corp. celebrated its 50th Anniversary on Sept. 1, 2, with an open house, entertainment and plant tours.

•

Hexcel Products Co. has leased an additional 24,000-sq ft building at 2398 Fourth St., Berkeley, Calif.

•

Tolerance Castings Co., 424 Seventh St., Rockford, Ill., has been formed to deal in the sales and engineering of precision, close tolerance castings.

•

Pittsburgh Plate Glass Co. will construct a huge, ultra-modern plate glass producing plant at Cumberland, Md.

•

Dow Chemical Co. has announced formation of a new associated company to manufacture Styron for molders in the British Isles. The company, incorporated as Distrene Ltd., is jointly owned by Dow and the **Distillers Co. Ltd.** of Edinburgh, Scotland. The firm will build a plant at Barry, South Wales.

•

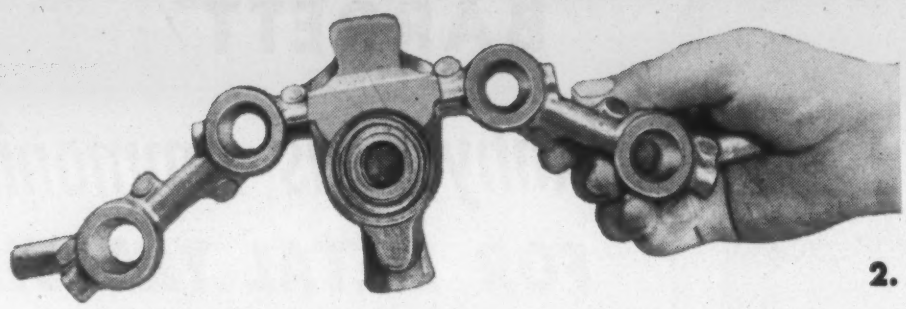
Metallizing Engineering Co., Inc., has moved its Eastern offices, factory and warehouse to 1101 Prospect Ave., Westbury, L. I., N. Y.

•

Verson Allsteel Press Co. will build a $1,500,000 addition to its plant facilities. The new addition will house the Fabricating Div.

(Continued on page 228)

Do You Have a Cast Part Problem that Must Be Solved Now?



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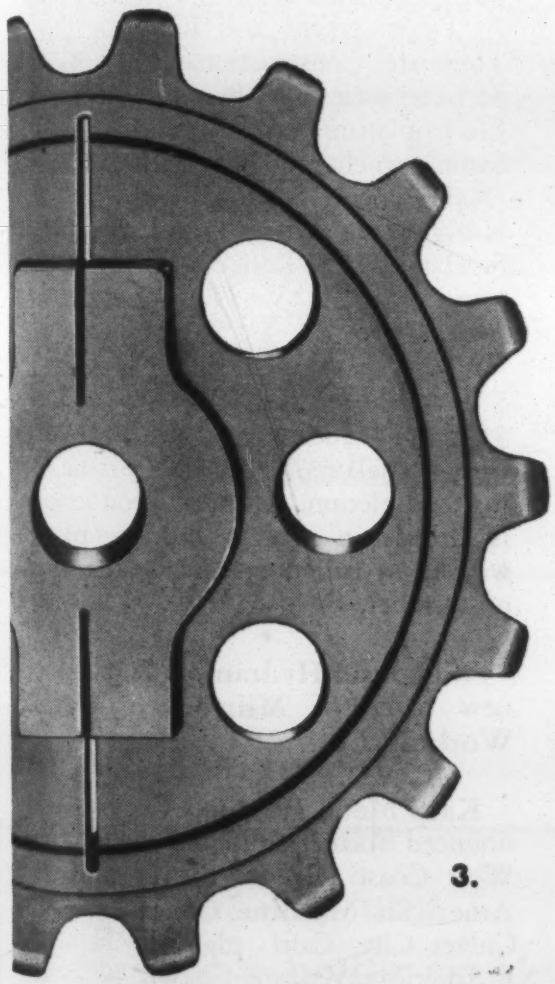


3.

A Howard representative, perhaps in your own area, helped to solve some of the production problems of these cast parts. Each part was produced by a different Howard casting process.

1. "Lost Wax" Precision Investment Cast 11-lb. helicopter cargo hook posed a problem because of size and complex shape . . . is one of largest parts produced by this process.
2. Permanent Mold Cast aluminum aircraft carburetor intake manifold requires fine detail in complex shape . . . must pass 100% x-ray inspection.
3. Sand Mold Cast alloy iron sprocket calls for wear resistant material to give long life even though in constant contact with dry sand.

Whatever your own cast part problem may be, it is nearer solution when you see your Howard representative. He helps solve your problems with three basic casting processes, gives you the widest selection of cast alloys in the industry today — beryllium copper, bronze, ductile iron, nickle-iron alloys, all types of steels, and virtually any aluminum and magnesium alloy.

To help you solve a cast part problem of design, material, cost or delivery, why not ask to see the Howard representative in your area today? There's no obligation.

CUT OUT AND MAIL ATTACHED TO YOUR BUSINESS LETTERHEAD

WE WOULD APPRECIATE DISCUSSING FOUNDRY ENGINEERING OF ONE OF OUR PARTS WITH THE HOWARD REPRESENTATIVE IN OUR AREA

NAME_____

POSITION_____

HOWARD FOUNDRY COMPANY

General offices:
1702 North Kostner Avenue • Chicago 39, Illinois

Plants at:
Chicago • Los Angeles • Milwaukee

WE LIKE TO BE KNOWN BY THE CUSTOMERS WE KEEP

For more information, turn to Reader Service Card, Circle No. 418

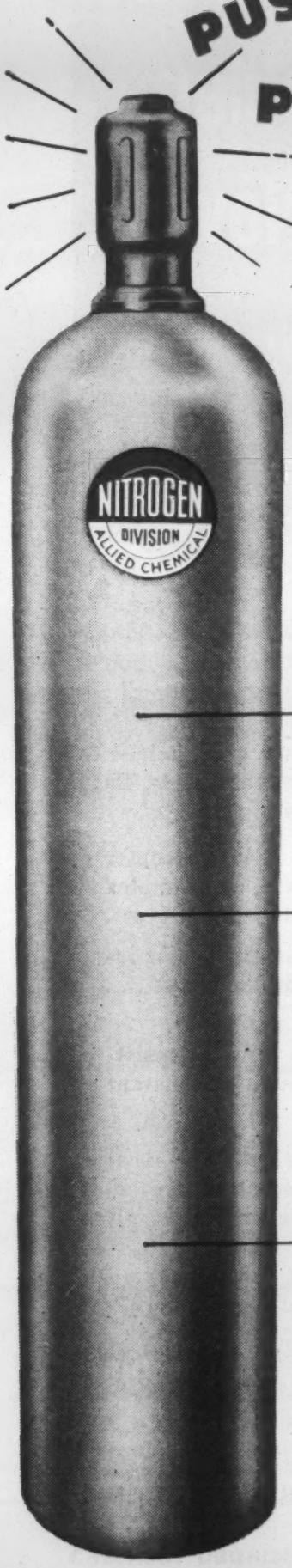
PUSH PRODUCTION UP

PUSH COSTS DOWN

with

BARRETT®
BRAND

Anhydrous Ammonia
FOR METAL TREATING



Here's Why in a Nutshell: You get 6750 cubic feet of mixed hydrogen and nitrogen when a single 150-pound cylinder of Barrett Brand Anhydrous Ammonia is disassociated at normal temperature and pressure. One of the most economical sources of disassociated hydrogen and nitrogen for metallurgical uses!

Economical For These Important Uses!
- –Protective atmosphere for bright annealing, brazing and powder metallurgy.
- –Nitriding of alloy steels and carbonitriding (Dry Cyaniding) for treatment of steel.
- –Case hardening of iron and steel with case depths up to 0.025 inches.
- –Sintering of metal powder compacts.
- –Augmenting corrosion – resistance treating for aluminum, magnesium, other light metals.
- –As a solvent in making electrolytes for electrolytic recovery of salts.

Fast Delivery. Barrett Brand Anhydrous Ammonia is stocked coast-to-coast in 150-, 100- and 50-lb. cylinders. An adequate supply of cylinders in all sizes helps assure fast delivery in the size you want. If you use *large* quantities, ask about our tank truck delivery service–you'll save money.

FREE Technical Help. Technicians specially trained in the use of Anhydrous Ammonia for metal treating will help you. No obligation. Also, valuable handbook, "Guide to Use of Barrett Ammonia in Cylinders" shows most economical usage; contains chemical properties, handling, charts, etc.

FREE! Ammonia Leak Detector Safety Kit! Pocket-size, this new handy kit quickly detects ammonia leaks. May be used over and over. Write today!

NITROGEN DIVISION ALLIED CHEMICAL

NITROGEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.
Ironton, Ohio • Orange, Texas • Omaha, Nebraska

For more information, turn to Reader Service Card, Circle No. 365

news of | COMPANIES

The Panelyte Div. of **St. Regis Paper Co.** has announced its entry into the vacuum forming field at Richmond, Ind.

•

National Vulcanized Fibre Co. has announced an administrational merger of its Fibre Specialty Phenolite Divs. Located in adjacent areas, the two have combined as the Kennett Plant.

•

Federal Telephone and Radio Co., a division of **International Telephone and Telegraph Corp.,** has organized an Instrument Div. for the manufacture and distribution in the United States of precision instruments for testing and measuring.

•

International Nickel Co., Inc. has established four new sections in its Development and Research Div. These are: Constructional Alloy Steels Section; with H. V. Beasley in charge; Electroplating Section, with C. H. Sample in charge; Inco Nickel Alloys Development Section, with T. E. Kihlgren in charge; and Stainless Steel and Heat-Resistant Alloys Section, with Dr. V. N. Krivobok in charge.

•

Lynchburg Foundry Co.'s new $1,250,000 addition for the manufacture of shell molded castings is nearing completion. Limited production is already in process and the plant will be in full operation by the end of October.

•

Wisconsin Hydraulics, Inc. is the new name of **Milwaukee Metal Working Co.**

•

Karp Metal Products Co. has announced formal affiliation with the West Coast Div. of the **H and B American Machine Co., Inc.** The Culver City, Calif. plant of H and B American Machine Co. will be used in manufacturing sheet metal products for west coast customers of Karp Metal Products Co.

•

Eltex Chemical Corp. has announced the acquisition of all rights to the Jetal Process for blackening ferrous metals by oxidation.

•

Kaiser Aluminum & Chemical Corp. will build a new multi-million dollar aluminum sheet and foil rolling mill on a 2500-acre Ohio River frontage near Ravenswood, W. Va.

(News of Societies on page 230)

Non-destructive inspection with a G-E x-ray unit insures a better product at lower cost

IF YOU'RE A USER OF CASTINGS, there's no need to buy blindly. With the all-seeing eye of x-ray, you can spot internal defects *before* costly machining. Even those deep-seated flaws that would not show up during machining can be eliminated as a source of potential failure of your product.

If you sell castings, on the other hand, x-ray inspection can protect your reputation — save your customers money and aggravation — give you a "plus" sales feature. In many foundries, x-ray is also used as a development tool — to disclose where savings can be made, designs improved, new techniques developed.

The possibilities for the profitable application of x-ray are as broad as industry itself. In addition to castings — weldments, intricate assemblies, the composition of the materials themselves can be checked.

Your G-E x-ray representative will be glad to analyze your requirements. With General Electric's line of 25 models, he can recommend the unit best suited to your needs. Call him today, or write X-Ray Department, General Electric Company, Milwaukee 1, Wis., Rm. \Z104.

General Electric x-ray apparatus can be yours . . . without initial capital investment . . . on the G-E Maxiservice® rental plan

Progress is Our Most Important Product

GENERAL ELECTRIC

For more information, turn to Reader Service Card, Circle No. 345

Available Now!!

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news of | SOCIETIES

The **Drop Forging Association** at its 19th Annual Meeting, elected as its president, K. E. Walter, president, The Alliance Drop Forging Co. Charles W. Stone, vice president, Interestate Drop Forge Co., was elected vice president.

•

The **American Society for Testing Materials** at its 58th Annual Meeting honored Sam Tour, president, Sam Tour & Co., with an Award of Merit "for long and fruitful service to the Society extending over many technical fields and administrative phases, for work on test methods, and especially for contributions to the metals and corrosion fields.

•

The **Franklin Institute of the State of Pennsylvania** has announced that Edwin T. Lorig, chief development engineer, U. S. Steel Corp., will be the recipient of a John Price Wetherill Medal at the Institute's annual Medal Day ceremonies.

•

The **Industrial Furnace Manufacturers Association, Inc.** has changed its name to Industrial Heating Equipment Association, Inc. Both the name and character of the old association are changed as the membership is broadened to include induction and dielectric heating equipment. The new name is also more consistent with government terminology and classification.

•

American Electroplaters' Society has elected Dr. Ralph A. Schaefer, vice president and materials development director, Clevite-Brush Co., as supreme president.

•

The **Society of Plastics Engineers, Inc.**, Southern California section, will sponsor an industrial conference coincident with the first **American Society of Tool Engineers'** Western Industrial Exposition and that society's national convention next March.

•

American Electroplaters' Society has reelected Dr. Earl J. Serfass, head of the Lehigh University Chemistry Dept., as chairman of its Research Committee.

(Meetings & Expositions on page 233)

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, national transportation meeting. Boston. Oct. 18-20, 1954.

AMERICAN SOCIETY FOR QUALITY CONTROL, New England conference. Albany. Oct. 21-23, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national diesel engine meeting. Cleveland. Oct. 26-28, 1954.

AMERICAN SOCIETY OF BODY ENGINEERS, annual technical convention. Detroit. Oct. 27-29, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS - AIME, joint fuels conference. Pittsburgh. Oct. 28-29, 1954.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Institute of Metals Div., fall meeting. Chicago. Nov. 1-3, 1954.

AMERICAN SOCIETY FOR METALS, national metal congress and exposition. Chicago. Nov. 1-5, 1954.

AMERICAN WELDING SOCIETY, fall meeting. Chicago. Nov. 1-5, 1954.

SOCIETY FOR NONDESTRUCTIVE TESTING, annual meeting. Chicago. Nov. 1-5, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national fuels and lubricants meeting. Tulsa. Nov. 4-5, 1954.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, annual meeting. Atlantic City. Nov. 8-11, 1954.

GRAY IRON FOUNDER'S SOCIETY, annual meeting. Hot Springs, Nov. 11-12, 1954.

MAGNESIUM ASSOCIATION, annual meeting. St. Louis. Nov. 15-17, 1954.

AMERICAN GAS ASSOCIATION, operating section, organization meetings. New York. Nov. 15-18, 1954.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, Western Region, annual conference. Los Angeles. Nov. 18-19, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. New York. Nov. 28-Dec. 3, 1954.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, electric furnace steel conference. Pittsburgh. Dec. 1-4, 1954.

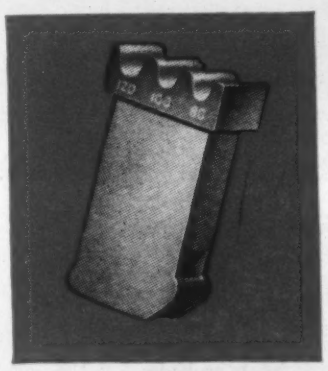
INSTITUTE OF THE AERONAUTICAL SCIENCES, INC., Wright Brothers Lecture. Washington, D. C. Dec. 17, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting. Detroit. Jan. 10-14, 1955.

Basic Materials Conference and Exposition. Philadelphia. June 12-16, 1955.

ONE COMPANY

SAVED THIS MUCH...



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News Digest

Metal Markets . . .

continued from page 11

settled this winter. The short range situation shapes up at closing date with Kennecott's Chilean mine (11,000 tons per month) still tied up in a political-labor wrangle; Phelps Dodge's refinery at El Paso (20,000 tons per month) closed up pending labor-management accord; Anaconda's Montana Mines (8500 tons per month) and two Arizona mines (6500 tons per month combined) on strike with no negotiations in evidence. Kennecott's settlement with the Mill Mine and Smelter Workers at its four domestic mines indicates that the copper prices will hold at 30¢ a pound, but if supplies get very short, the price may go up and stay up.

Lead and Zinc

The Government's decision to stockpile lead and zinc rather than increase tariffs has resulted in rising, firming prices for the metals. The GSA policy showed a change when the latest contracts for stockpile zinc and lead were let on the basis of average prices prevailing in October rather than on price at the date of contract.

Lead prices jumped half a cent, ostensibly as a result of London prices. St. Joseph Lead Co. led the increase and other companies followed. The general consensus of buyers is that lead prices will stay firm or increase.

Steel

The booming construction industry—8% ahead of its August 1953 record—has been a mainstay in the steel market. Structural steels and plate are about the only steel products on which the mills will not absorb the freight charges. Competition is so severe in all fields that mills began absorbing freight charges on electrical steels in September. Steel producers, slumping along at below 65% capacity have been "feeling a better tone" in the market for some time, though buyers seem to be very slow about whistling in their orders. With so many of the big automobile companies working off inventories of last years cars and closing down for extended retooling periods, the pace probably will not pick up until late in the

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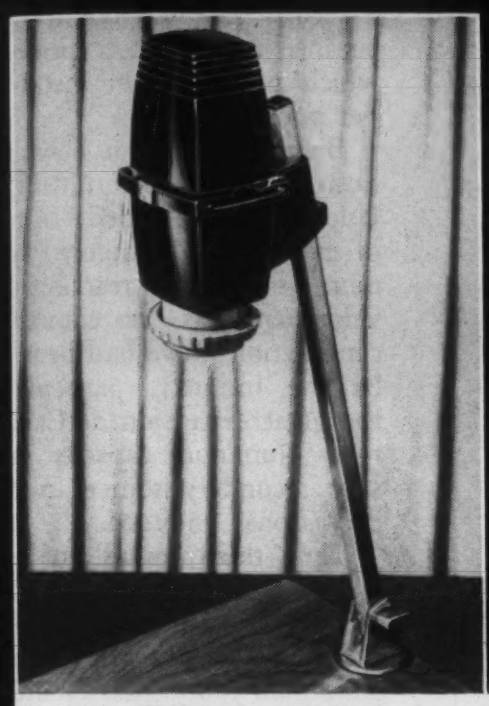

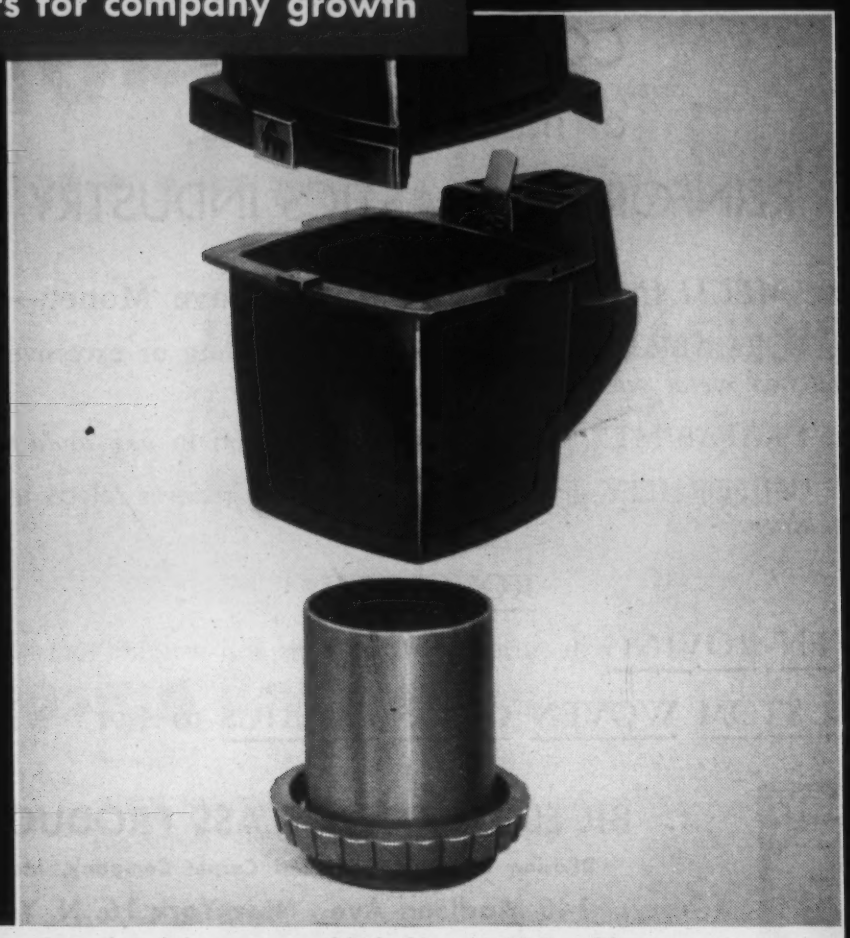

FR Corp.'s new photo enlarger lens housing barrel and sleeve are molded of Lustrex Hi-Test 88 styrene; upper housing of Resinox phenolic plastic.

FR's designers create first low-cost, quality enlarger with

HI-TEST 88 MONSANTO LUSTREX Styrene Plastic

The FR Corporation's new photo enlarger is a notable example of how sound, functional design in plastics can slash production, finishing and assembly costs – savings that made possible an inexpensive, quality instrument aimed at a big, untapped market.

The lens housing barrel and sleeve are molded of Monsanto's Lustrex Hi-Test 88 styrene – and they're classics of engineered economy. Complex shapes that would be difficult, time-consuming and expensive to fabricate by conventional processes are quickly formed in a "one-shot" molding operation with Lustrex Hi-Test 88 styrene . . . *and at a cost far below that of designs in other materials!* Ready for assembly when it comes from the mold *– no finishing needed!*

The FR enlarger's upper housing, made of Monsanto's Resinox phenolic plastic, contains a high intensity, low-wattage lamp which produces plenty of heat . . . sure death to most materials. *But not to Resinox!* It's ruggedly resistant to heat, resists chipping and rusting. FR's designers also know that Resinox molds with flawless quality, eliminating costly finishing.

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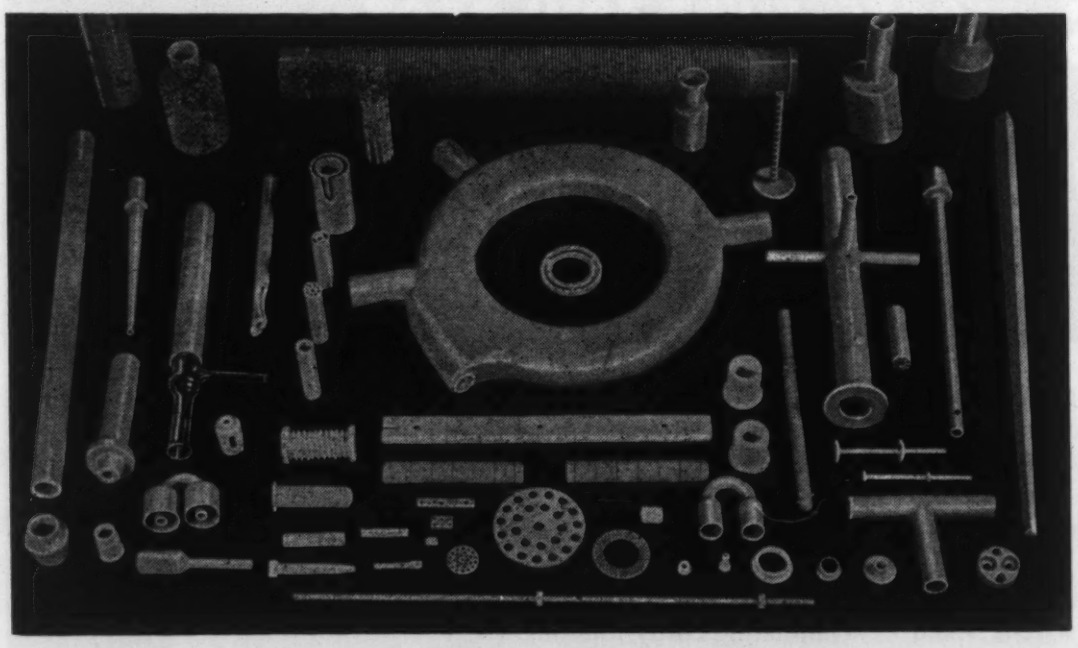

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News Digest

fourth quarter when the lines really get rolling for the spring market.

Aluminum

Aluminum production continues at a record pace without too much resistance to the latest price increase, which put the light metal at 22.2¢ per pound.

Biggest long range news in the industry was the government's cancellation of the so called "third round" of expansion. Strangely, the Aluminum Association's reaction to the development was "no comment." The cancellation move had been expected by the industry, particularly since the great expansion of Canada's primary aluminum capacity provides a sure secondary source in the event of national emergency.

The "third round" of expansion was to have been the culmination of the government's fast tax write off program for increasing the primary aluminum production facilities in the U. S. In 1950, domestic capacity was about a billion and a half pounds per year of primary aluminum. The first and second rounds of expansion virtually doubled domestic capacity. The "third round" proposed in 1952, would have added another 800,000,000 lb of aluminum capacity. The Office of Defense Mobilization, announced its decision to cancel the third round after a study of latest supply and military requirement figures. The conclusion at which they arrived was that military, defense supporting, and civilian requirements could be fulfilled at present capacity. The ODM also claimed that supplies were adequate for all out mobilization, and that additional primary facilities could be constructed and be in operation before stockpiled material was exhausted. Canadian expansion of primary capacity, which is considerably above the amount expected in 1952, played a key role in the decision to withdraw the expansion program.

Mercury

Quicksilver prices have acted like the mercury in a thermometer on a hot day in St. Louis. Soon after the government pegged minimum prices at $225, ostensibly to encourage domestic producers to open marginal mines, the price of the heavy metal skyrocketed. A flock of unconfirmed rumors to the effect that the AEC

SURFACE DECARBURIZATION PROBLEMS ... ELIMINATED

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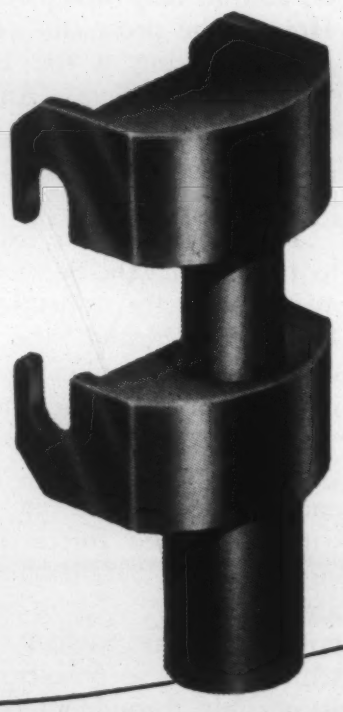
INVESTMENT CASTINGS by **ARWOOD'S** new Homocarb Furnace

Design Engineers

Arwood can investment cast intricate or simple shapes at great savings with the assurance of uniform quality — we can guarantee castings with .001" maximum decarburization.



Here's How

Arwood has pioneered again — recognizing the need for investment castings free of surface decarburization, Arwood is the first foundry to install carbon restoration equipment.

NOW...

Carbon and low alloy steel investment castings (1020, 3120, 4130, 4140 and 6150) can now meet all of the most exact metallurgical specifications — including freedom from surface decarburization.

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"Alloy Selection and Design for Precision Casting"

For the RECORD

These two mating units, pilot and anchor for aircraft clamp ring fastening screw, were previously milled from bar stock.

Using the carbon restoration unit, Arwood was able to meet the strict metallurgical specifications necessary to assure dependable performance.

ALLOY: 4140 (.001" Max. Decarb.)
HEAT TREAT: Double normalize, carbon restore, quench, temper
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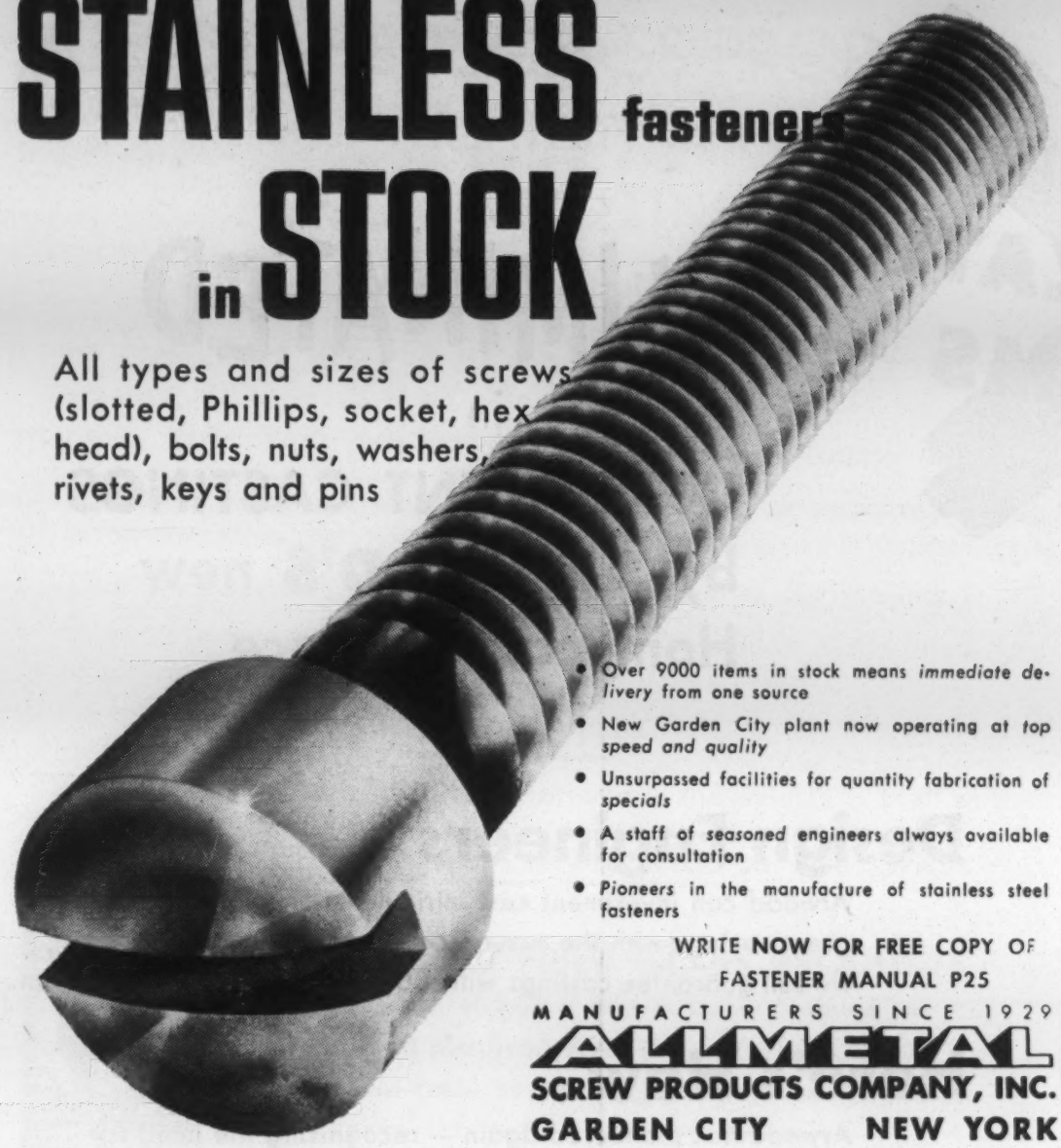

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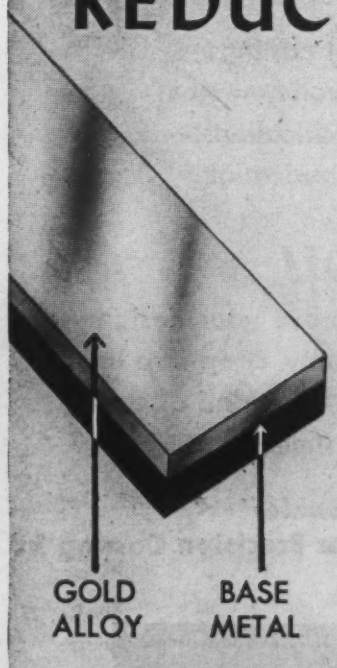
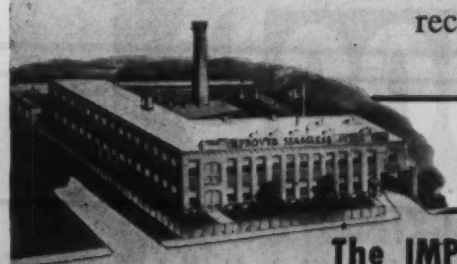


THE TREND toward high gold content (69% gold, 6% platinum, 25% silver, for example) rapidly leads to mounting costs for contact parts. These costs can be greatly reduced by using an *Improved* laminated metal. A precious metal alloy is solidly and permanently bonded to an inexpensive, non-ferrous base metal with the finished product just as effective as its more costly counterpart.

This material can be had in wire or tubing form as well as in the bar form illustrated. Quotations rendered upon receipt of your specifications.



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News Digest

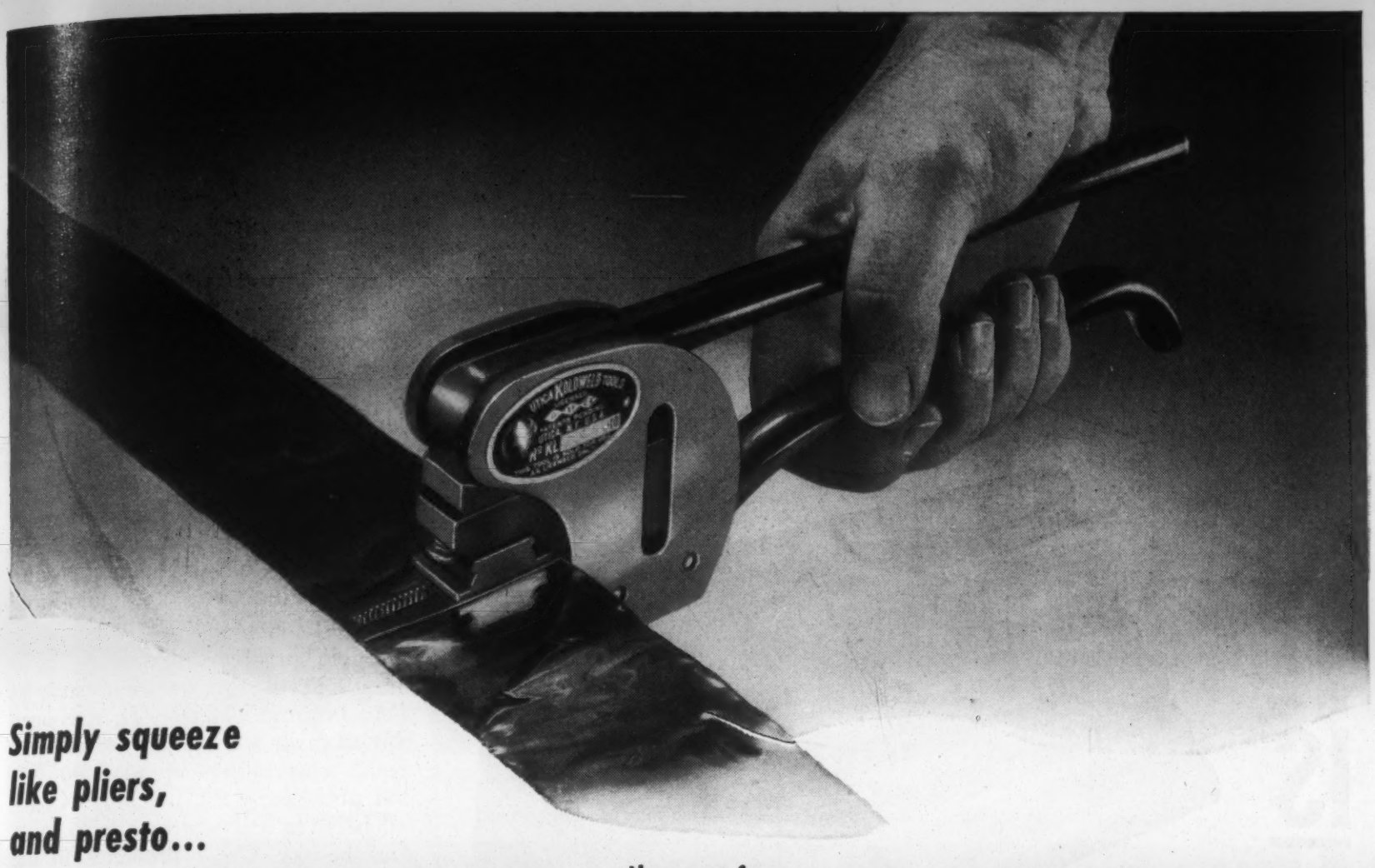
needs large quantities of mercury for "atomic" use undoubtedly resulted in increased speculation in the field and served to accelerate the price spiral. At press time, a 76-lb flask of mercury brought $303, compared to $188 one year ago. Trading volume was far down, with little mercury offered or bought. Consuming manufacturers were buying as little as possible to barely meet production needs, and inventories were falling fast.

Need Problems? Here are 200!

Tired of the same old grind? Looking for new worlds to conquer? The National Inventor's Council, U. S. Department of Commerce, may be able to help dissipate that ennui. Hot off the press and available free for the asking is the 1954 list of Technical Problems Affecting National Defense, a selection of 200 posers the armed forces would like to solve.

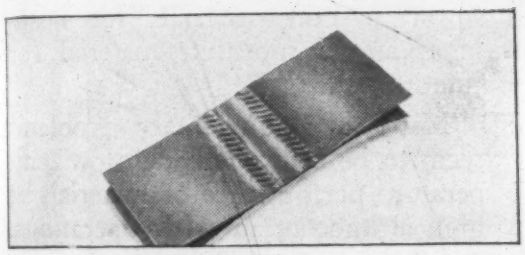
The concept of the list dates back to 1940, when the Secretary of Commerce, with the concurrence of the President, created the Inventor's Council in the belief that "there is inherent in the American people a vast reservoir of inventive talent coupled with knowledge and experience." The Council, in cooperation with the armed forces, prepares an annual list of problems and general areas which are most in need of technological advancement. By disseminating these problems as widely as possible throughout the technical and lay public, the council rightly believes that chances for their solution are improved. In the fourteen years of its existence, the council has received from the public more than 300,000 proposals, some of which have resulted in outstanding savings of manpower and material and considerable improvement in weapon performance.

This year's list includes about 130 problems still active from previous lists, with short precis of any progress in the field, and 70 new problems. The list is not issued in an attempt to find firms or organizations interested in obtaining development contracts, nor to find products already on the market, since it is assumed that established products and research organizations have been brought to the attention of the proper govern-

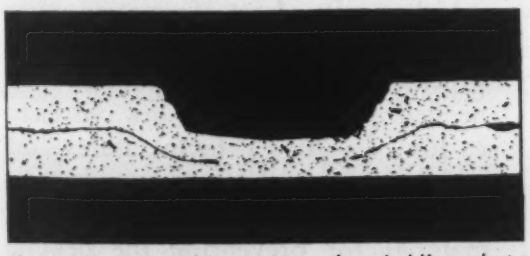


Simply squeeze like pliers, and presto...

ALUMINUM or other non-ferrous metal sheet IS KOLDWELDED!



You never saw aluminum welded so quick and easy! Photo shows .004 aluminum foil shielding just as it came out of the UTICA® Lapwelder.



You get a real *weld*, not just a bond. Microphoto shows lapweld in .004 aluminum foil. Note Koldwelded area in center shows actual inter-molecular flow of metal . . . *both* foil sheets become a single homogeneous unit (Photo made by Alcoa Process Dev. Labs., Welding Section, Project K-15).

BUTTWELDS TOO

UTICA® Koldwelding tool KB-14 for butt-welding (above) makes perfect welds without heat; electricity or flux in just seconds. Operates with many non-ferrous metals.

The UTICA® Koldwelding tool KL-10 for lapwelding weighs less than 3 lbs. It's easily portable from job to job. Yet it does equal or better work than conventional welding equipment which costs more and is non-portable.

Koldwelding employs no heat or electricity or flux of any kind. No special skill is required and no flash occurs. Welding is by pressure alone. Yet Koldwelds are as strong or stronger than welds made by any other method.

One set of UTICA precision dies will Koldweld all gauges of foil from an over all thickness of .002 to .026, and other interchangeable dies will Koldweld sheets to a maximum thickness of .040—total weld .080.

To get more facts and data on this new type of welding send today for UTICA *Koldwelding brochure.*

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If you require *extra* qualities in your high alloy pipe, investigate DURASPUN Centrifugally Cast Pipe. We can produce it in OD ranging from 2½" to 24" and in lengths up to 15' according to diameter. Our experience in the field of centrifugal high alloy castings dates back to 1931. Our experience in the field of static high alloy casting goes back to 1922. We can give you good service.

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News Digest

ment agency through standard procurement channels.

Innovations Needed

Many of the problems posed in the new list are concerned with materials development, and others deal with the kind of innovation in design fully capable of solution in a small machine shop or even by an imaginative doodler. Many are omnipresent problems, "A Dirt Immune Hydraulic Valve", "A Jam-Proof, Dustproof, Quick-Disconnect, Multi-Contact Plug" and a "Radio-Proof Blasting Cap", being typical.

Some problems appear to be a little out of the question, such as "An Improved Metal—There is need for an easily worked alloy which will resist temperatures up to 5000 F.", but presumably the Inventor's Council believes it is worthwhile to shoot for the sky. Other problems in the materials field seem to be more solvable, such as smokeless and flashless rocket propellants; corrosion resistant ball, roller and needle bearings, lower friction materials for bushings; and a substitute material for jute in sandbags.

Many of the military problems seem to be concerned with low temperature performance of materials at high altitude or in arctic operations. A substitute for Wolverine fur for ruffing is needed, as this fur and center skunk stripe are the only ones which resist frost formation. Improved casting resins or methods to protect electronic components are needed with relatively low viscosity at low (—70 F) temperatures and resistance to cracking over wide temperature variations. A method or material for preventing the deposit of ice between sprocket and track on track laying vehicles is needed. Packings and lubrication for oxygen compressors with a wider temperature range than present materials (32 to 212 F) is a listed problem. Storage batteries for arctic use, a substitute for neoprene that will not embrittle —70 F, and a down and feather substitute for sleepings bags are still listed as problems, though the nickel-cadmium cell, Kel F elastomers, and specially treated chicken feathers would appear to be possible solutions.

Materials Problems

In addition to the super-superalloy problem for high temperatures, the

The crankshaft in the modern V-8 engine requires the ultimate in forging technique. Today's high compression engines, with continually increasing horsepower, further emphasize the importance of forging quality.

Wyman-Gordon technical know-how assures quality essential for maximum physical properties, uniform machinability and balance control . . . crankshaft forging specialists since the introduction of the internal combustion engine.

WYMAN-GORDON

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER, MASSACHUSETTS

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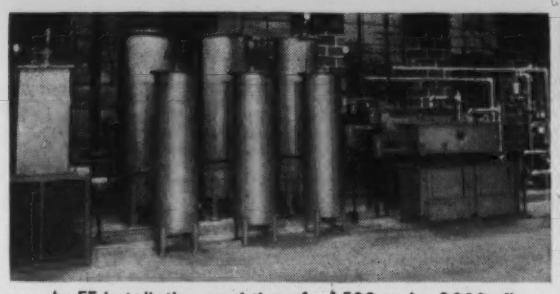
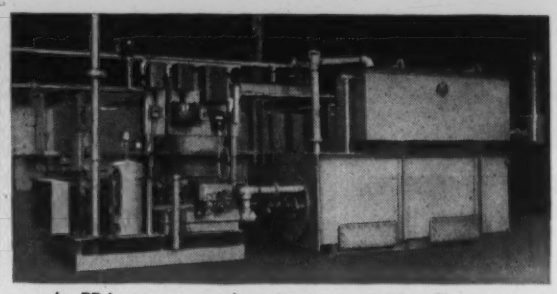
For more information, turn to Reader Service Card, Circle No. 424

For more information, turn to Reader Service Card, Circle No. 305



An EF installation consisting of a 1500 and a 3000 cfh exothermic horizontal water cooled type special atmosphere unit, each with desulphurizing towers and refrigerators for bright annealing steel and copper, and clean annealing brass.



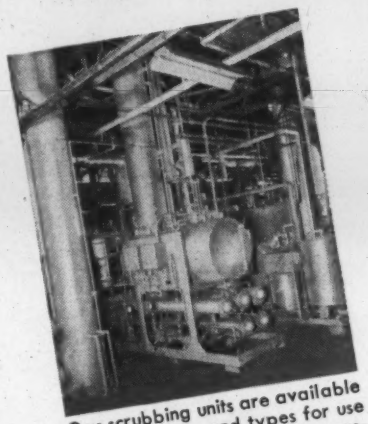
An EF kerosene exothermic gas generator. These are also built in several sizes and types for producing special atmospheres for use in bright annealing copper and steel products in areas where fuel gases are not available.

EF

SPECIAL ATMOSPHERE EQUIPMENT

For any Heat Treating Process... any Capacity

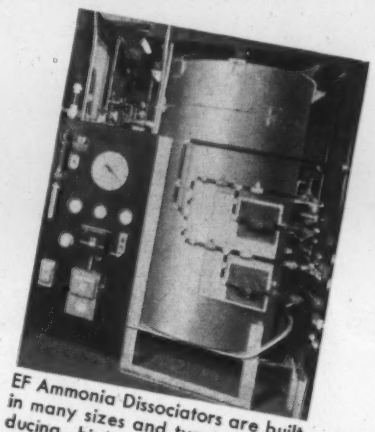
Long Experience = High Efficiency + Low Maintenance



Gas scrubbing units are available in several sizes and types for use with any type of EF special atmosphere generating equipment where it may be necessary to remove CO_2 or H_2S.

● As pioneers in the development and use of equipment for producing low cost special atmospheres, we are in position to furnish a wide range of reliable, thoroughly tested special atmosphere units, including endothermic and exothermic gas generators, ammonia dissociators, refrigerators, dryers, desulphurizers, gas scrubbing units and other special atmosphere equipment—equipment with a reputation for high efficiency,—and low maintenance and operating costs.

Submit your furnace or special atmosphere problems to experienced engineers — *IT PAYS*



EF Ammonia Dissociators are built in many sizes and types for producing highly reducing atmospheres as required for bright annealing stainless; and other annealing and normalizing processes and preventing decarburization.

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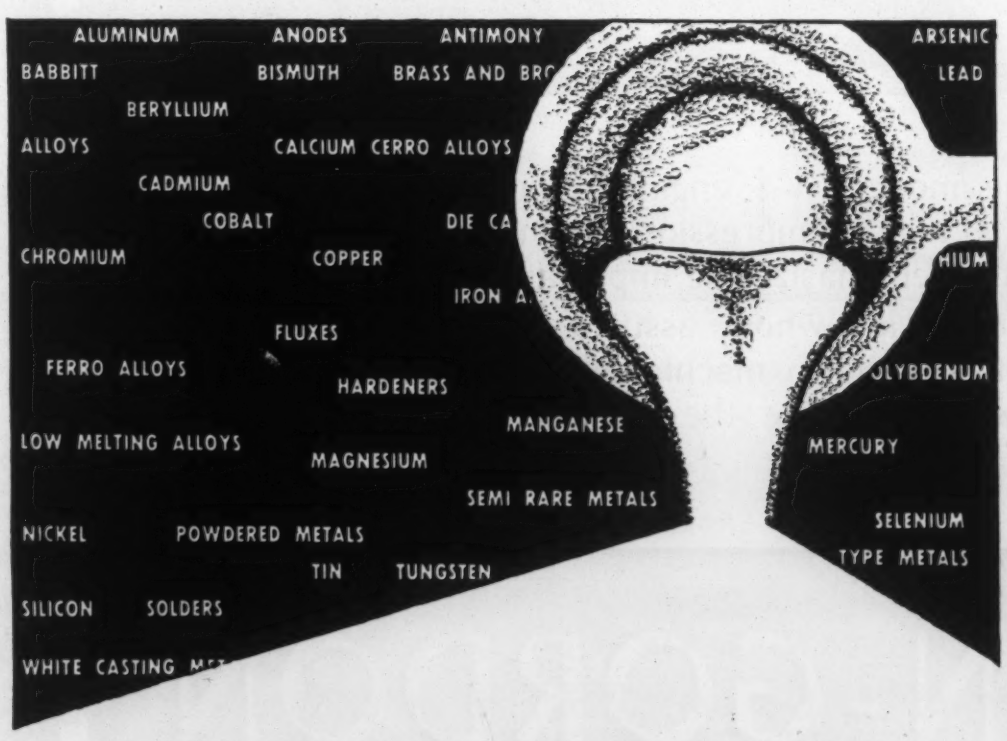
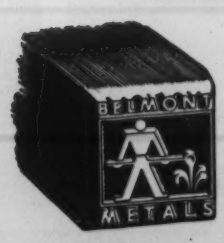


all metals • all alloys • all forms

Rx for Metal Troubles—

"BETTER BUY BELMONT"



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Belmont

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News Digest

Inventor's Council list of problems is generally concerned with almost any materials more resistant to high temperature. Specifically: light alloys serviceable to 1000 F; sandwich core materials retaining strength and characteristics up to 600 F, an erosion resistant metallic material with a minimum elongation of 10%, machineable at room temperature, with a hot Brinell of 200 at 1500 F; a means for improving the hot hard qualities of electrodeposited chromium; and so on.

And . . .

Other materials problems include: high strength magnesium or aluminum alloys for casting (75,000 psi); a substitute for radium having a minimum of gamma radiation for illuminating scales, etc., on fire control equipment; metal-to-metal adhesives with a shear strength of 2500 psi at 500 F which can be applied without excessive control of processing variables; a material for arresting hooks for aircraft; a resurfacer to eliminate haze scratches in acrylic plastic surfaces; a semiconductor material, the color of which would depend upon its conductivity type; a supersonic radome with minimum aberration which is relatively immune to dust, rain and ice erosion; long-burning, solid-propellant material which can be throttled; a consumable rocket motor; a case material for lead acid batteries with or without liner which is lighter than those in use.

Testing methods which need solving include a non-destructive test for adhesive bonded metal to metal joints; a carbon monoxide detector for aircraft personnel use; devices for testing and recording data at temperatures from 200 to 1000 F; detection method for defects or general inadequacies in sandwich core materials; tests for materials subject to erosion by high temperature gases; tests for adhesion of organic coatings to metals and wood; better tests for weld toughness; and others.

So, if you are hiding that destructive ray, tougher elastomer for tank tracks, or explosion proof high pressure oxygen tank in your cellar or in the back of your mind, type out your ideas and send them to the Inventor's Council, U. S. Department of Commerce. They will protect your interest and see that proper development proceeds.

(More News on page 244)

Why accept frequent furnace repairs and production losses as "routine"? Today, there's one . . .

Sure way to avoid shutdowns

WHAT CAUSES MOST REFRACTORY FAILURES? Usually one small area is at fault. A spot that had to take more abuse than the rest of the furnace . . . and couldn't. Couldn't because it was made of the same refractories as the rest of the furnace. Couldn't because it was not protected by materials *specifically designed* to resist corrosion . . . or flame impingement . . . or erosion . . . or extreme heat . . . or whatever combined conditions caused the localized failure.

That's where CARBORUNDUM's super refractories fit in. These products are "custom designed" to do what's above-and-beyond other refractories. They are the "armor plate" agents, designed to make emergency furnace breakdowns a rarity.

THEY ARE ALSO ENTIRELY DIFFERENT. Some of their properties have no inherent connection with ordinary refractories. For example, the diamond-like hardness of silicon carbide, which gives it superior wear resistance. Or the corrosion resistance of electric furnace mullite. Or the chemical stability of aluminum oxide.

They're also very different, one from another. Some conduct heat very rapidly. Others insulate. Some are made of bonded grain, others of bubbles or hollow spheres bonded together. Still others are cast, like metals, into an impervious, ivory-like structure. But all are inherently strong, resistant to extreme heat, and highly durable. And each, in its place, can pretty much eliminate emergency shutdowns, and extend on-line time.

WE'D LIKE TO WORK WITH YOU toward this end. Our engineers know what materials to apply—and where. For theirs is the experience of the world's largest supplier of super refractories. As a starter, send the coupon.

CARBORUNDUM
Registered Trademark

Dept. R-104, Refractories Division
The Carborundum Co., Perth Amboy, N. J.

☐ As a starter, send literature only.

☐ I'd like first-hand information. Please phone for appointment.

Name _____ **Position** _____

Company _____

Address _____

For more information, turn to Reader Service Card, Circle No. 426

HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field—less than 1%—with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

AJAX ELECTRIC FURNACE CORP.

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THE AJAX WYATT INDUCTION MELTING FURNACE

ASSOCIATE COMPANIES: Ajax Electrothermic Corporation, Ajax-Northrup High Frequency Induction Furnaces; Ajax Electric Company, Inc. The Ajax-Hultgren Electric Salt Bath Furnace; Ajax Engineering Corporation, Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces

For a Money-Back Guarantee OF LONGER SERVICE *specify*

PROMET THE Engineered BRONZE

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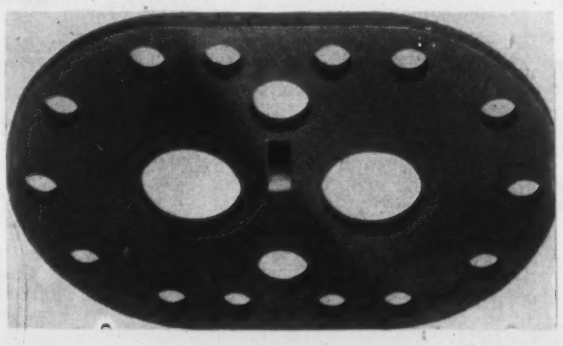

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Standard and special formulas developed for specific or unusual conditions. Assure the best combination of physical properties, strength in tension and compression, hardness, and ability to sustain both static and dynamic loading.

Protect moving parts from injury, scoring, and seizing due to temporary interruption or failure of lubrication.

Will not powder under the most severe conditions of service. Available rough cast or machined to precisely controlled tolerances. Can be machined at surface speeds up to 875 lineal feet per minute.

Castings to your patterns—any size, shape or section—delivered as scheduled and specified. Pattern making, designing and machining when required.

Write for free literature and service data sheets. Send blueprints, conditions of operation and other data for recommendations and quotations. You are invited to discuss your bearing problem with our metallurgists, engineers, and laboratory technicians.

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News Digest

Introduce Silicone Fabric Finish

Upholstery fabrics impregnated with silicone resins were introduced to the public by Dow Chemical Corp. at the National Home Furnishing Show in New York. Twelve furniture manufacturers cooperated in the introduction of the fabric treatment by displaying furniture and draperies treated with silicones.

The treatment of upholstery fabrics is the latest in a long series of silicone developments. The application of silicones to fabrics imparts water repellancy, spot and stain resistance, abrasion resistance and an improved hand. The treatment is not affected by laundering or dry cleaning solvents. Upholstery treated with silicones is resistant to oily spots and stains. Such spots are removed with a solvent without leaving a solvent ring.

Ferro-Alloy Prices Hiked

Revisions in prices for some silicon alloys and special alloy products, because of higher production costs, were announced by Electro Metallurgical Co., a Division of Union Carbide and Carbon Corp. The company stated that costs have been increasing as a result of higher wage rates and higher prices for certain raw materials, neither of which had been reflected in selling prices.

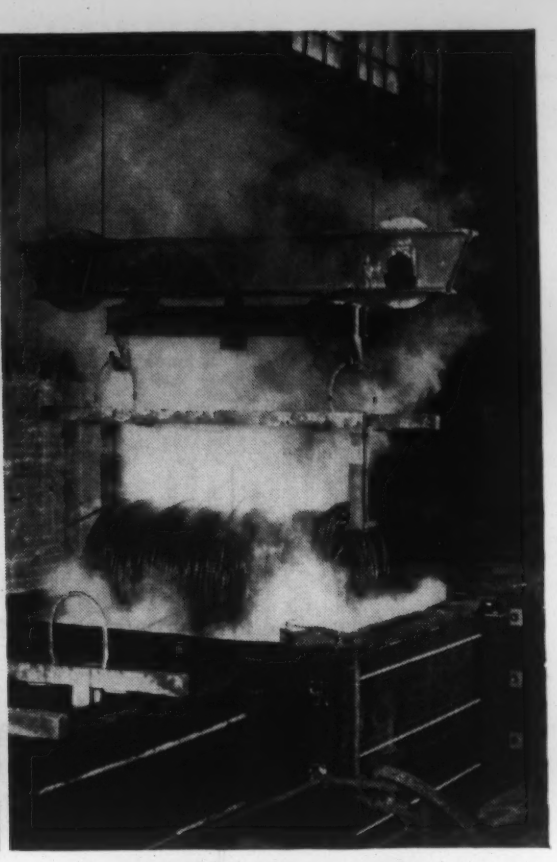
Employees of Electromet were recently granted increases in wage rates which conform closely to those granted in other basic industries, the company reported. In some instances, as many as three increases in wages have been made over a period of time during which there was no compensating increase in prices. Minor increases in the cost of some raw materials going into the silicon alloys have become effective. For special alloys, such as ferrocolumbium and ferrotantalum-columbium, some essential raw materials have actually doubled in cost, the company stated.

The new prices became effective October 1 for contract users and earlier in September on a spot basis.

The announcement of these increases follows a reduction of ½¢ a pound on standard ferromanganese, and 4/10¢ a pound on ferromanga-

TOOL STEEL SHEETS

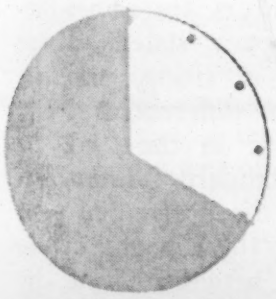
STAINLESS STEEL BAR STOCK



CARBON STEEL WIRE

You can safely descale most metals in 20 minutes or less

WITH THE DU PONT SODIUM HYDRIDE PROCESS



In 10 to 20 minutes, sheets, bars, wire, rods, forgings and fabricated articles are completely descaled with the Du Pont Sodium Hydride Descaling Process. Even heavily scaled forgings (½" scale thickness) take less than an hour. And in only 15 seconds you can get cold reduced-annealed strip clean and bright!

With hydride descaling, there's never any danger of etching or pitting . . . never a costly reject due to loss of gauge. Base metal is always protected, *since bath action stops the instant scale is reduced.* And retreatments are rarely needed with most metals. One pass through the sodium hydride bath will do the job completely.

TECHNICAL SERVICE AVAILABLE

If you are descaling metals which are unaffected by fused caustic at 700°F., it will be to your advantage to talk to us about the Du Pont Sodium Hydride Process. Du Pont pioneered this modern descaling method and can bring a depth of technical experience to bear on your descaling problems.

There's no cost for this service which includes laboratory investigation of problems, plus expert aid in construction, installation and operation of the process. Just call our nearest district office or send in coupon below.

DISTRICT AND SALES OFFICES: Baltimore • Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Kansas City* • Los Angeles • New York • Philadelphia • San Francisco *Barada & Page, Inc.

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Electrochemicals Dept., Wilmington 98, Del.

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☐ Please have one of your technical men call. I am interested in descaling _____

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Firm _____

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City _____ *State* _____

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Sponge Iron Powder

for

Powder Metallurgy Fabrication

& Other Metallurgical Purposes

For better green strength,

For increased tensile strength,

For uniformity,

Use ANCOR 80

Call in your powder metallurgy

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MEMBER mpa METAL POWDER ASSOCIATION

Sellers of Hoeganaes Sponge Iron Powder

For more information, turn to Reader Service Card, Circle No. 500

News Digest

nese briquets, both of which became effective on September 1.

Typical new prices, and the amount of change, are as follows:

Alloying Material	*Price per lb Si*	*Change*
50% Ferrosilicon	12.0¢	+1.2¢
90% Ferrosilicon	17.25	0.25
Ferrochrome Silicon	12.0	1.2
Low Carbon Ferromanganese Low Phosphorus Grade	32.0¢	2.0¢
	Per Running Pound	
Manganese Metal (not electrolytic)	45.0¢	8.8¢
	Per Pound Contained Chromium	
Chromium Metal 0.50% Carbon Grade	$1.16	$0.04
	Per Pound Contained Columbium	
Ferrocolumbium	$12.00	$2.50
	Per Pound Contained Columbium plus Tantalum	
Ferrotantalum-Columbium	$6.25	$1.50
	Per Running Pound	
Standard Ferromanganese	9.5¢	—0.5¢

All these changes are across-the-board, the company stated. There are no changes in sizing, packing, quantity, or spot differentials. The only exception is in the 2-in. by Down size of standard ferromanganese, for which the differential over lump drops by 2/10¢ a pound, while the differential between 2 in. by Down and ½ in. by Down increases by 2/10¢ a pound.

Because of the decrease in standard ferromanganese prices, a charge for shipment in box-type pallets will apply, effective Oct. 1, to cover the cost of this palletizing. This charge will be $4 a net ton for pallets holding 3000 pounds, and $6 a net ton for pallets holding 2000 pounds.

High-Top Iron Process Licensed to U.S. Steel

The high top pressure process for increasing pig iron production from blast furnaces got a recent boost from U. S. Steel Corp., which signed a license agreement with Arthur D. Little, Inc., the research organization

FAIRPRENE®

synthetic elastic compositions

MATERIAL ENGINEERING SERVICE

SHEET STOCKS • COATED FABRICS • INDUSTRIAL ADHESIVES

DU PONT

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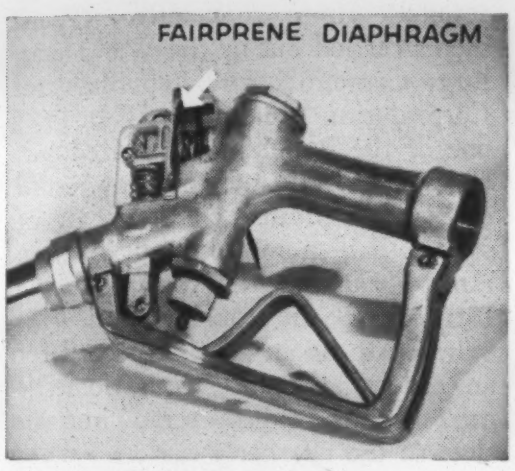
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

How Du Pont FAIRPRENE is "tailor-made" of any rubber coated on any fabric, to fit your needs



FAIRPRENE diaphragm for fuel nozzle says "when"

When a driver tells a service-station attendant to "fill 'er up," the patented "Safety-Fill" nozzle shown above automatically shuts off the fuel flow when the tank is full. This sensitive device—made by the Buckeye Iron and Brass Works, Dayton, Ohio—works through the employment of a diaphragm made of a Du Pont "Fairprene" synthetic elastic composition.

Here's how it works: When the tank is full, air escaping from the tank through a small valve into the nozzle is cut off. The resulting vacuum in a chamber causes the "Fairprene" diaphragm to jump back. This instantly stops the flow of fuel, just as the flow stops when the handle is released by the operator manually.

Through the action of this highly pressure-sensitive "Fairprene" diaphragm, fuel overflow is avoided. The result is elimination of waste, and protection for the finish of customers' cars.

Technical help for you

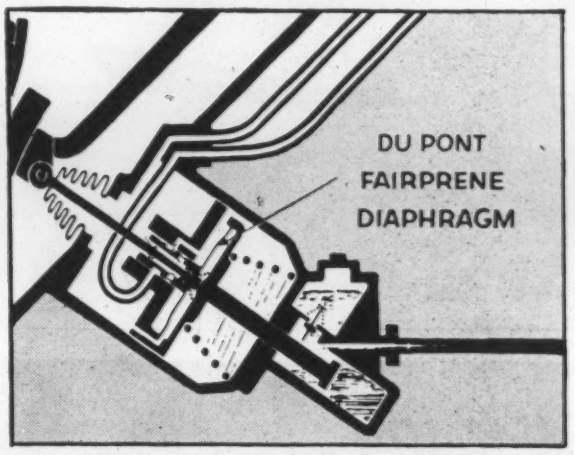
Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products, or for improving your present products or manufacturing methods. They'll gladly work with you in engineering special grades of "Fairprene" to meet your specific needs. For prompt assistance, fill out and mail the coupon today!

DU PONT "Fairprene"* synthetic elastic compositions are made by impregnating, spreading or calendering elastomers on one or both sides of a woven fabric. The particular elastic coating and the particular fabric depend on the job the "Fairprene" product must do. The elastic might be (alone or in combination) neoprene, Buna-N, Buna-S, Butyl, Thiokol or a silicone. The fabric could be cotton, ORLON, nylon, rayon, glass, felt, asbestos, or some other fabric.

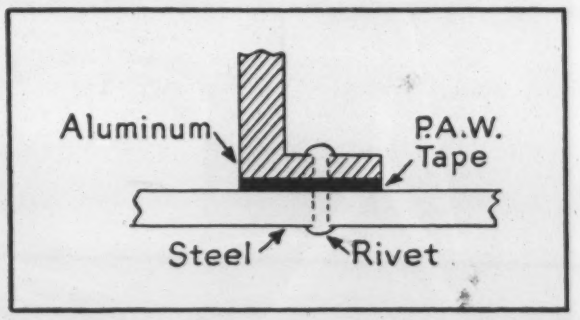
The specific properties of a "Fairprene" composition will depend on the combination used, which in turn depends on the end use in view. Du Pont engineers can "tailor" these properties to fit the job. But, in general, "Fairprene" synthetic elastic compositions are resistant to petroleum oils, greases, gasoline and alcohol . . . to natural aging in air and oxygen . . . to extremes of heat and cold . . . to flex fatigue . . . to deteriorating action of fresh and salt water.

In order to be sure you get the specific "Fairprene" product that's best for your application, it's important to determine the service conditions that have to be faced. Du Pont engineers will be glad to work with you on this. Then they can recommend the grade of "Fairprene" your job needs—or develop and test a new "Fairprene" product for you, if necessary.

Among the many applications in which "Fairprene" compositions have already proved successful are sensitive diaphragms, all types of gaskets, apron and protective cloth materials, watertight seam sealants and grease seals and oil-line coverings.



In the Bendix "Treddle-vac"® hydraulic vacuum-power brake, a "Fairprene" diaphragm controls piston action by counteracting atmospheric pressure.



"Fairprene" P.A.W. Tape seals out moisture at joints . . . inhibits corrosion . . . prevents electrolytic action between dissimilar metals.

**Fairprene" is Du Pont's registered trade-mark for line of products made from synthetic elastomers available in form of coated fabrics, sheet stocks without abric insert and adhesives.*

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"engineered to do the job better"

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Fabrics Division, Fairfield, Conn.

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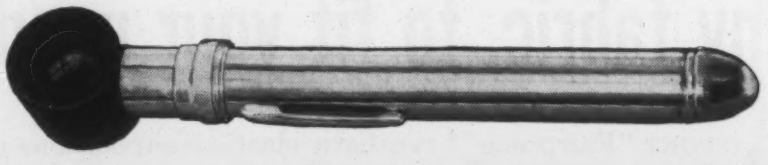
New! Illuminated 10x Pocket Magnifier



WRITE for new handbook and catalog "Industrial Magnifiers—How to Choose and Use Them." Bausch & Lomb Optical Company, 50334 Bausch St., Rochester 2, N. Y.

Cut waste, get faster, surer inspection by fitting the magnifier to the job. This new Bausch & Lomb Illuminated Coddington floods entire viewing field with bright light *through* the lens, permitting quick, accurate on-the-spot inspection, without need for outside lighting. Image quality is excellent! Carry this new magnifier with you always—anywhere.....$7.50

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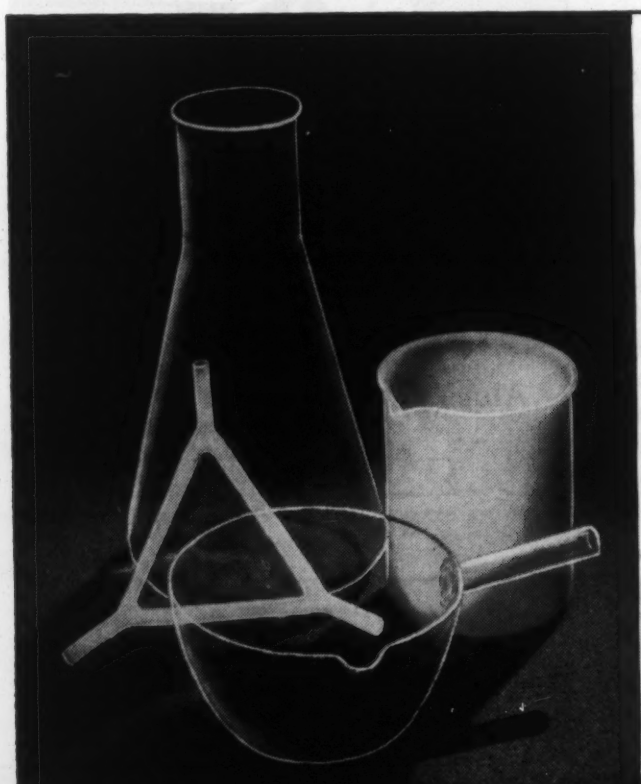

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VITREOUS VITREOSIL SILICA

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News Digest

responsible for introducing and pioneering the process.

The top pressure operation is accomplished by throttling the gases from the blast furnace, which slows down the reducing gas and builds up pressure in the furnace. The process reduces coke consumption and cuts flue dust losses more than a third. Production increases reported by the nine licensed high-top furnaces now operating in this country are as high as 15%.

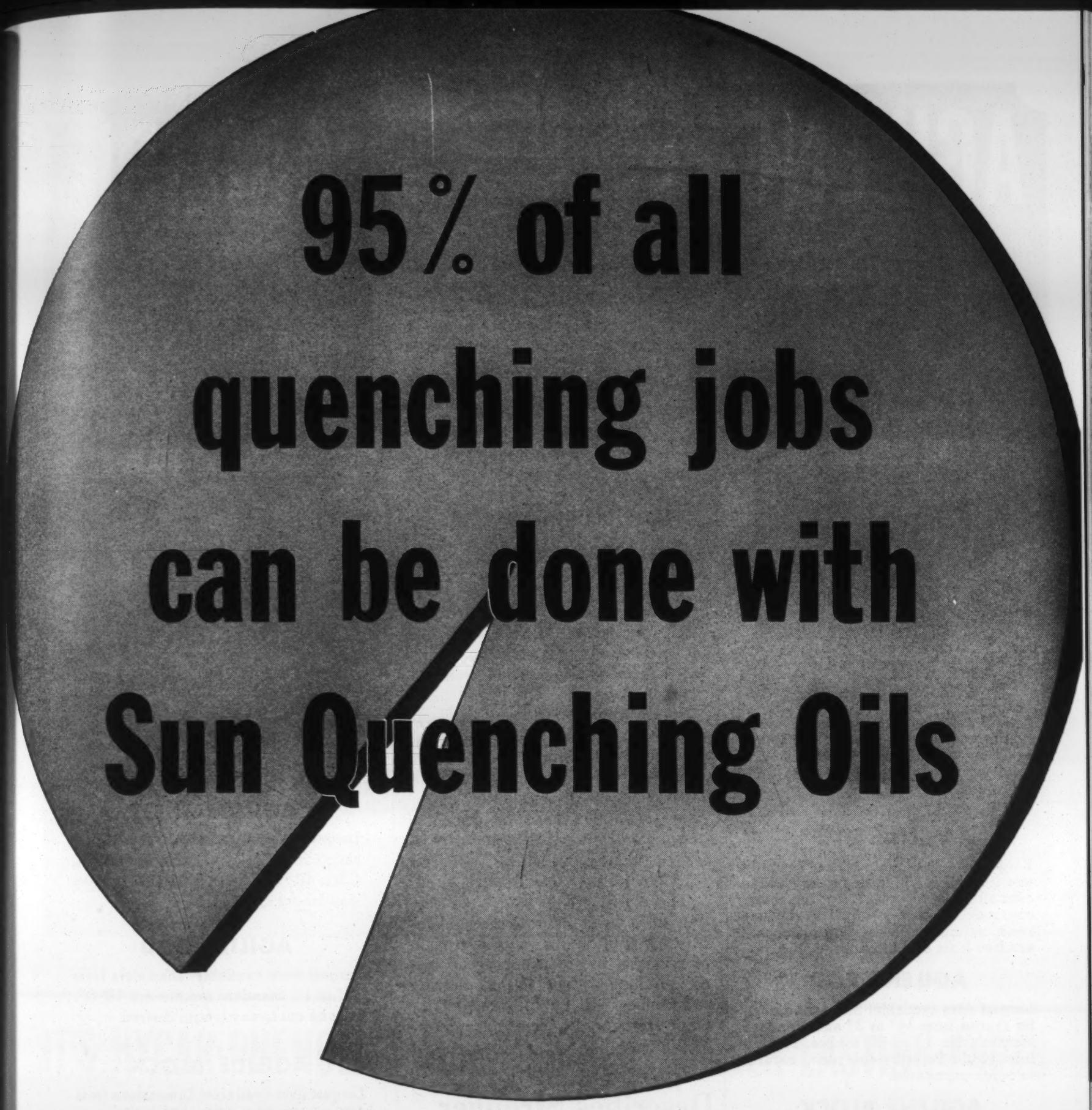
High top blast furnace operation resulted from cooperative experiments carried out by the War Metallurgy Committee and Republic Steel Corp. during World War II. In 1953 one of the Republic pressurized furnaces set an all time company record of pig iron production. Its record of over a half a million tons of iron ranks it among the top producing furnaces in the country, and it is believed to be an all time record for an Amercan Furnace using domestic ore without adding scrap iron or steel to the charge.

In addition to the nine licensed furnaces operating in the United States, English and European steel companies also use the process, and it is known that Russia has converted many of its furnaces to the new process without bothering with licensing agreements from the U. S. research firm.

Britain Buys Plans For Titanium Plant

Two British firms have bought proprietary furnace designs and operating know-how for melting titanium and titanium alloy ingots from the Titanium Metals Corp. of America. William Jessop & Sons, Ltd., and another British metals producer plan to set up facilities based on the TMCA designs to melt sponge produced by England's sole titanium sponge producer, Imperial Chemical Industries' 1500-ton plant. Several British firms are installing titanium processing equipment to melt ICI sponge and titanium imported from the U. S. and Japan.

The Titanium Metals Co. of America has developed the proprietary furnace designs over the past four years. TMCA's furnaces use a vacuum double melting technique rather than slight positive pressure with inert atmosphere. The process



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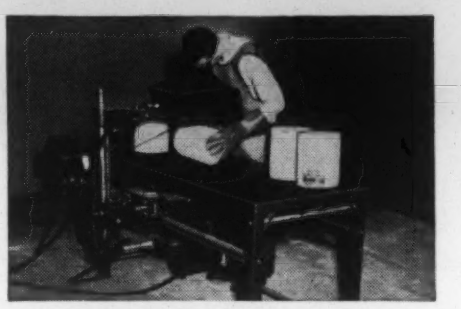
(POLYETHYLENE)
for ULTIMATE
CORROSION RESISTANCE

BY THE AGILE HOT GAS WELDING, FLAME SPRAYING, and FLOC-COATING METHODS



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AGILENE SHEET

Largest sheets available! They range in size from 1/16" to 1" in thickness and the over all size is 48" x 72". Agilene sheets are molded from virgin Polyethylene resin, natural or black pigmented, and are free from air inclusions.

AGILENE ROD

Largest sizes available! Standard diameter ranges from 1/2" to 3" and standard lengths from 12 to 60 inches. Molded from virgin Polyethylene resin, natural or black pigmented.

AGILENE BLOCK

Largest sizes available! Standard dimensions range from 12" x 12" x 1" to 12" x 12" x 4" molded from virgin Polyethylene resin, natural or black pigmented. Larger sizes also available.

MOLDINGS

Largest sizes available! Up to 1,000 pounds.

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For more information, Circle No. 470

News Digest

is now turning out 4000-lb ingots of titanium.

William Jessop and Sons, Ltd. has supplied aircraft steels to British manufacturers for many years and is now expanding into the titanium field. The second British firm, not identified by TMCA, in addition to purchasing the furnace plan, is reported to have also purchased rights to the technique for remelting titanium scrap developed in this country by TMCA.

Wear Resistance Clinic Scheduled

A textile clinic, for exchanging technical information on wear-resistant parts for textile machinery, will be held for approximately 200 industry representatives in Greenville, South Carolina on November 15.

Jointly sponsored by Poe Hardware & Supply Co., Greenville, and Carboloy Department of General Electric Company, Detroit, the clinic was developed in recognition of the increasing importance of cemented carbide wear parts in the industry to meet specific cost-cutting problems with how-to-do-it information.

The clinic will include a description of cemented carbides and their existing applications, and discussion of potential use for stepping up textile production. The formal meeting and dinner will be followed by in-plant work on problems facing carbide users.

Describes Stronger Hi-temp Polyester

A new plastic developed for aircraft, which is claimed to withstand high temperatures better than aluminum and magnesium, was described at the 126th national meeting of the American Chemical Society.

8 Days at 500 F

The new material held up under exposure to temperature of 500 F for eight days, according to Dr. William Cummings, a chemist of the United States Rubber Co.'s Naugatuck Chemical Div.

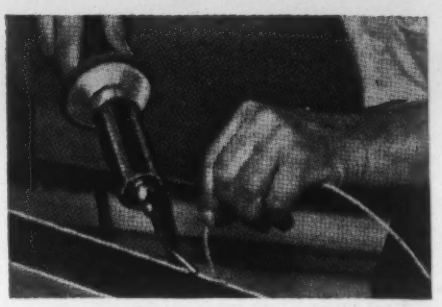
Wide applications were foreseen by Dr. Cummings for this new plastic in airplanes, ducts for hot gases, and high temperature molds and dies.

(Continued on page 152)

AGILIDE

(NON-PLASTICIZED POLYVINYL CHLORIDE)
for ULTIMATE
CORROSION RESISTANCE

BY THE AGILE HOT GAS WELDING TECHNIQUE



For Hot Gas Thermo-Plastic Welding (electrically operated 110 volt gun) complete with 15 feet each inert gas or air hose, rubber covered flexible electric cord. Ask for Bulletin "Hot Gas Welding."

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Largest sizes available! Diameters from 1/4" to 1". Standard lengths are 10' 0". May be cut to any length desired.

AGILIDE BLOCK

Largest sizes available! Dimensions from 12" x 12" x 1" to 12" x 12" x 4".

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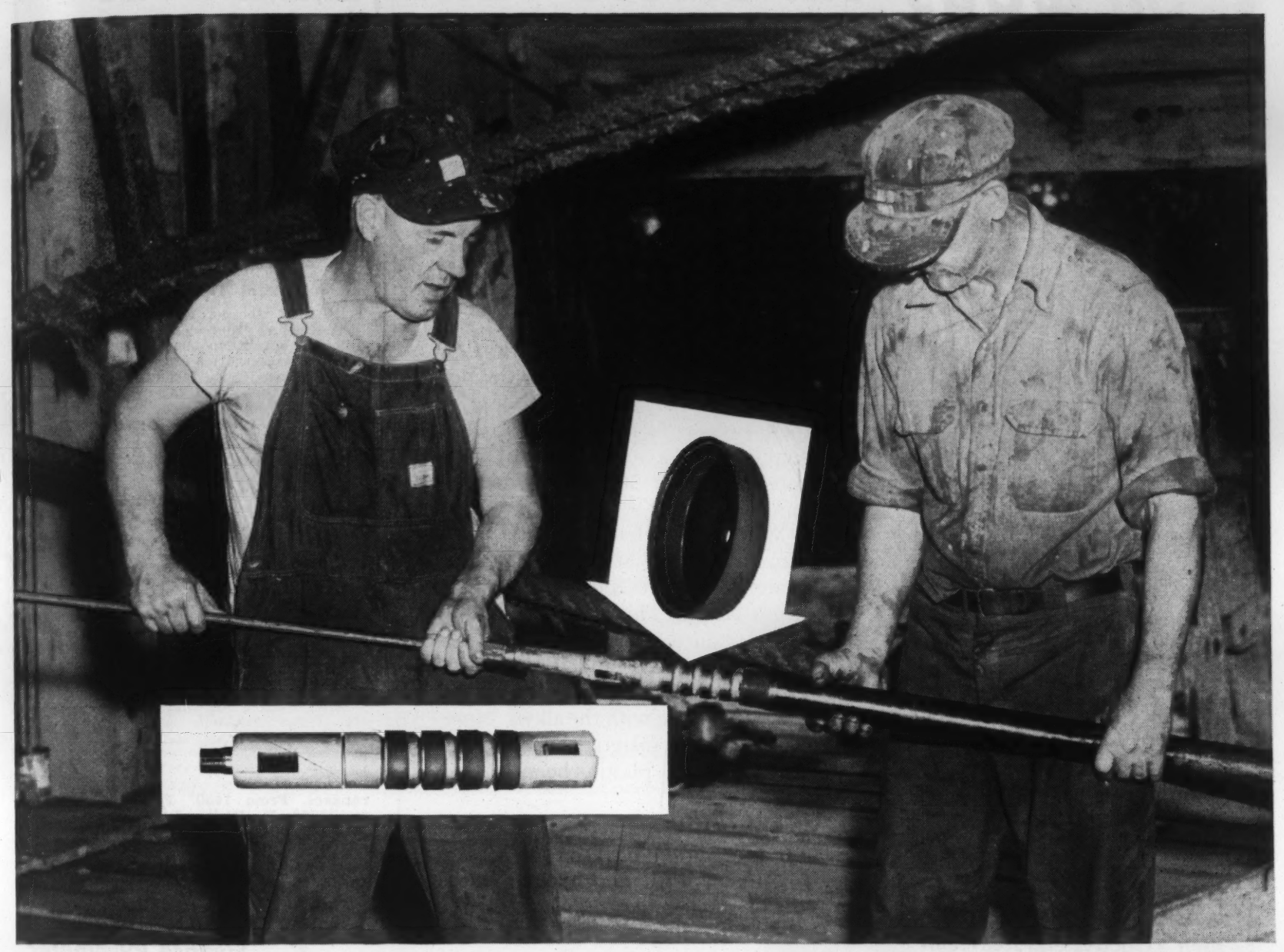
Another new development using

B. F. Goodrich Chemical *raw materials*



The pump rod cups are made by The Dragon Manufacturing Company, Marietta, Ohio. B. F. Goodrich Chemical Company supplies only the Hycar rubber.

IT'S HYCAR-PHENOLICS FOR TOUGHER, LONGER LASTING PARTS

HERE'S a combination that can handle the *really tough* jobs—Hycar American rubber and phenolic resins. The oil well pump rod cups pictured above are molded from a Hycar-phenolic blend. They maintain high pump efficiency long after other cups would fail—extend the continuous operation of the pumps by as much as three months. Result—users gain higher well production and lower labor costs.

This outstanding performance is made possible by combining Hycar with a phenolic resin. The result is a compound with better shock, abrasion and fatigue resistance than ordinary rigid materials. Furthermore, Hycar-phenolics resist the deteriorating effects of oil and many chemicals and, because of their excellent processing characteristics, frequently solve the problem of molding intricate parts.

Hycar, either alone or in combination with other materials, may help you develop products that will stand up under severe conditions.

For technical information, please write Dept. HR-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Hycar
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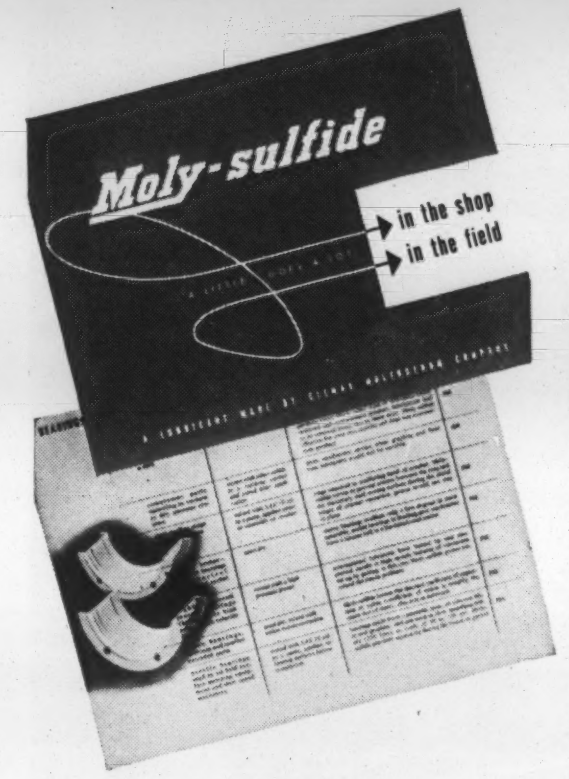
GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

For more information, turn to Reader Service Card, Circle No. 338

154 ideas on ways to use...



154 varied applications of molybdenum sulfide in the shop and in the field are described in a new booklet now available. This solid-film lubricant has demonstrated unique anti-friction properties under conditions of extreme pressure, high velocity, elevated temperature, or chemical attack.

The 40-page booklet contains the records of solved lubrication problems — some might solve your own. Fill in the coupon below, attach it to your letterhead and send it off today.

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MOLY

MM-10 MS-6A

For more information, Circle No. 371

News Digest

Three Resins Used

The plastic is a laminate made with glass cloth and three different resins. Tests of the material's resistance to bending showed that the new plastic is 50% stronger than the next best plastic of this type, a laminate containing two of the same resins, he observed. A resin mixture of maleic alkyd and TAC (triallyl cyanurate) produced a plastic that withstood a bending force of 19,000 psi after it had been heated at 500 F for eight days, he continued, while the new laminate made from a mixture of these two resins plus DET (a diallyl bicycloheptene dicarboxylate), resisted a force of 30,200 psi under the same conditions.

When only DET was added to the alkyd resin, the strength after heat treatment was 10,200 psi, Dr. Cummings added. This value was below that obtained with TAC, yet the use of both DET and TAC gave a stronger plastic than did the use of either one alone with the alkyd. Moreover, the new material will cost less than the TAC plastic, he predicted.

Less Crazing

The addition of DET to a resin mixture of TAC and alkyd resulted in a plastic less likely to show surface effects. Crazing was least evident when a resin mixture of one part of TAC and one part of DET were added to two parts of alkyd, according to Dr. Cummings. A smaller proportion of DET permitted more crazing with a corresponding loss of strength, and greater amounts of DET introduced the low-strength characteristics of the DET alone.

Best Yet

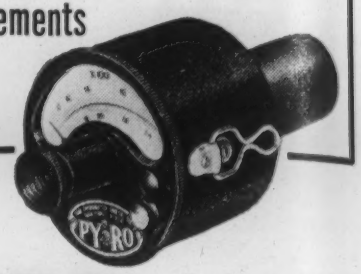
Other laminates using various resins known to reduce the crazing effect in TAC-alkyd plastics were tested, but none was found to have the heat-resistant properties of the DET mixture, he said.

Marvin Botwick, also of the Naugatuck Div., was co-author of the report, which was presented before the Society's Div. of Industrial and Engineering Chemistry.

●

Watch For
The Basic Materials Conference and Exhibition. Philadelphia. June 12-16, 1955.

PYRO
Instruments for Precision Temperature Measurements



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Tells spot temperatures instantly in heat-treating furnaces, kilns forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature indicated on direct-reading dial at a press of the button. Any operator can use it. Two double-ranges from 1000° F. to 3400° F. Write for FREE Catalog No. 100.

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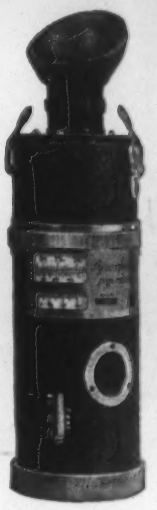

Determines temperatures of minute spots, fast-moving objects and smallest streams—at a glance! No correction charts or accessories needed. Easy to use—weights only 3 lbs. Special types available to show true spout and pouring temps. of molten ferrous metal measured in open. Five stock rangees. From 1400° F. to 7700° F. Write for FREE Catalog No. 85.

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The ideal instrument for all plant and laboratory surface and sub-surface temperature measurements. Available with large selection of thermocouples and extension arms for all jobs. Designed for ruggedness and accuracy . . . it features automatic cold end compensation, large 4¾" direct reading dial and shock, moisture and dust-proofed shielded steel housing. 5 stock ranges 0-300°F. to 0-1200°F. Ask for catalog No. 168.

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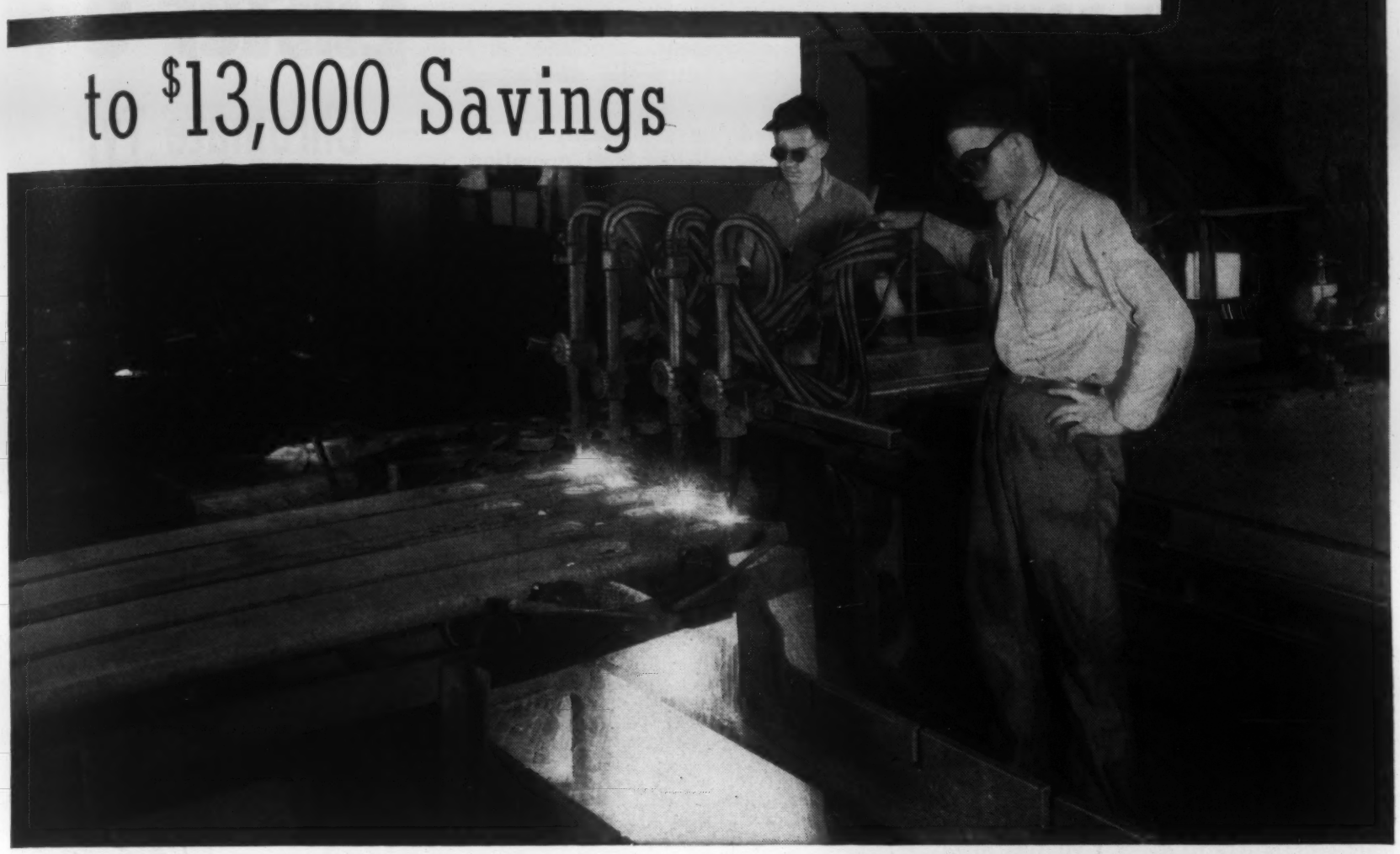
Machine-Cutting Clears the Way to $13,000 Savings

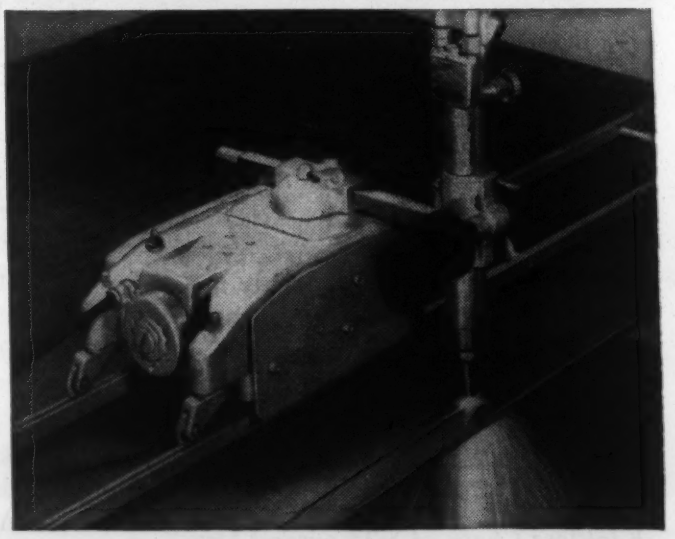


One steel company is saving up to $13,000 a year by using oxygen shape-cutting machines for making ingot and pan links from steel plate.

Previously these parts were forged at an annual cost of approximately $30,000. The speed and accuracy of oxygen shape-cutting cut costs to $17,000 a year—a savings of more than two dollars on each of the 5,000 parts made.

Machine-cutting setups are speeding fabrication and cutting costs throughout industry. Whatever your part-producing needs are—cutting hundreds of parts at one time, or one-of-a-kind turnout—there are LINDE oxygen shape-cutting machines to help you save hours and dollars in production time.

LINDE service engineers will be glad to help you determine the shape-cutting setup to best serve your job needs. Call your local LINDE representative for more information. Start saving now—call him today.



This lightweight portable cutting machine weighs only 38-lbs., and can cut metals up to 10-in. thick. It can cut straight lines, circles, and plate edge preparations in from 4-in. to 32-in. per minute.

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For more information, turn to Reader Service Card, Circle No. 449

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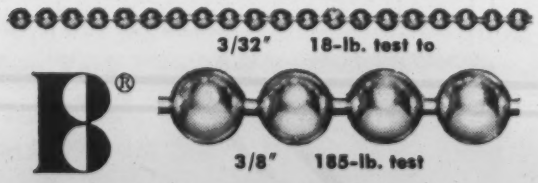
Because of its unique characteristics, Bead Chain is frequently employed by alert designers to make a simple, low-cost and highly efficient sprocket drive. Ideal for many products, it has been proved on business machines, television tuners, venetian blinds, etc. Slippage is absolutely prevented as each bead fits into an individual pocket.

Just check the qualities you want in a drive chain against the qualities offered by Bead Chain: It will not kink, bind, jam or shrink. It is completely flexible, strong, light, rustproof and long-wearing. Because every bead acts as a universal joint, changes in direction of pull are easily made.

SOLVES MANY DESIGN PROBLEMS

BEAD CHAIN — the chain you think of first as an electric light pull is truly "the Kinkless Chain of a Thousand Uses" — serving many industries and solving a wide variety of design problems. It may pay you well to check your product for opportunities to reduce costs and add sales appeal with this unique chain.

Bead Chain is available in many metals and finishes, and in five sizes, from:



The BEAD CHAIN® Mfg. Co.

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Manufacturers of: BEAD CHAIN — the kinkless chain of a thousand uses, for fishing tackle, novelty, plumbing, electrical, jewelry and industrial products; MULTI-SWAGE — the most economical method of producing small tubular metal parts for electronic and mechanical applications.

For more information, Circle No. 484

1954 Metal Show

continued from page 13

space will be filled by 444 firms exhibiting equipment, products, and services relevant to the metals industry.

There will be a diversity of interests in the display and operation equipment at the hundreds of exhibitor booths—ranging from new developments in spot welding to the latest techniques of testing and finishing. The exhibit area will be open from Nov. 1 through 5.

Technical Sessions

The regular technical programs of all Societies with the exception of the Special Libraries Association, which meets on Thursday and Friday, Nov. 4 and 5, will begin on Monday, Nov. 1. See page 15 for consolidated program of all societies.

ASM Activities

On Saturday and Sunday, Oct. 30 and 31, the ASM will hold its annual seminar, which will treat the subject *Imperfections and Impurities*. Prominent metallurgists will discuss recent advances in knowledge of the basic mechanisms affecting the performance of metals.

The American Society for Metals will hold its annual metallographic exhibit during the entire week of the Metal Show. Micrographs and macrographs displayed will qualify exhibitors in a contest which offers substantial recognition as well as cash award for the best entry. Classifications for the exhibit are divided into 11 categories: tool steels and tool materials; stainless and heat resisting steels; other steels and irons; aluminum, magnesium, beryllium, titanium and their alloys; copper, zinc, lead, nickel and their alloys; metals and alloys not otherwise classified; series showing transitions or changes during processing; surface phenomena; results by unconventional techniques (other than electron micrographs); and slags, inclusions, refractories, cermets.

The annual meeting of the ASM will take place Wednesday morning morning Nov. 3 in the grand ballroom of the Palmer House and will include the ASM Annual Campbell Memorial Lecture, which will be delivered this year by Kent R. Van Horn of the Aluminum Company of America. The Annual Banquet of the ASM will conclude the official ac-

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Brilliant finish and outstanding corrosion protection on cadmium.

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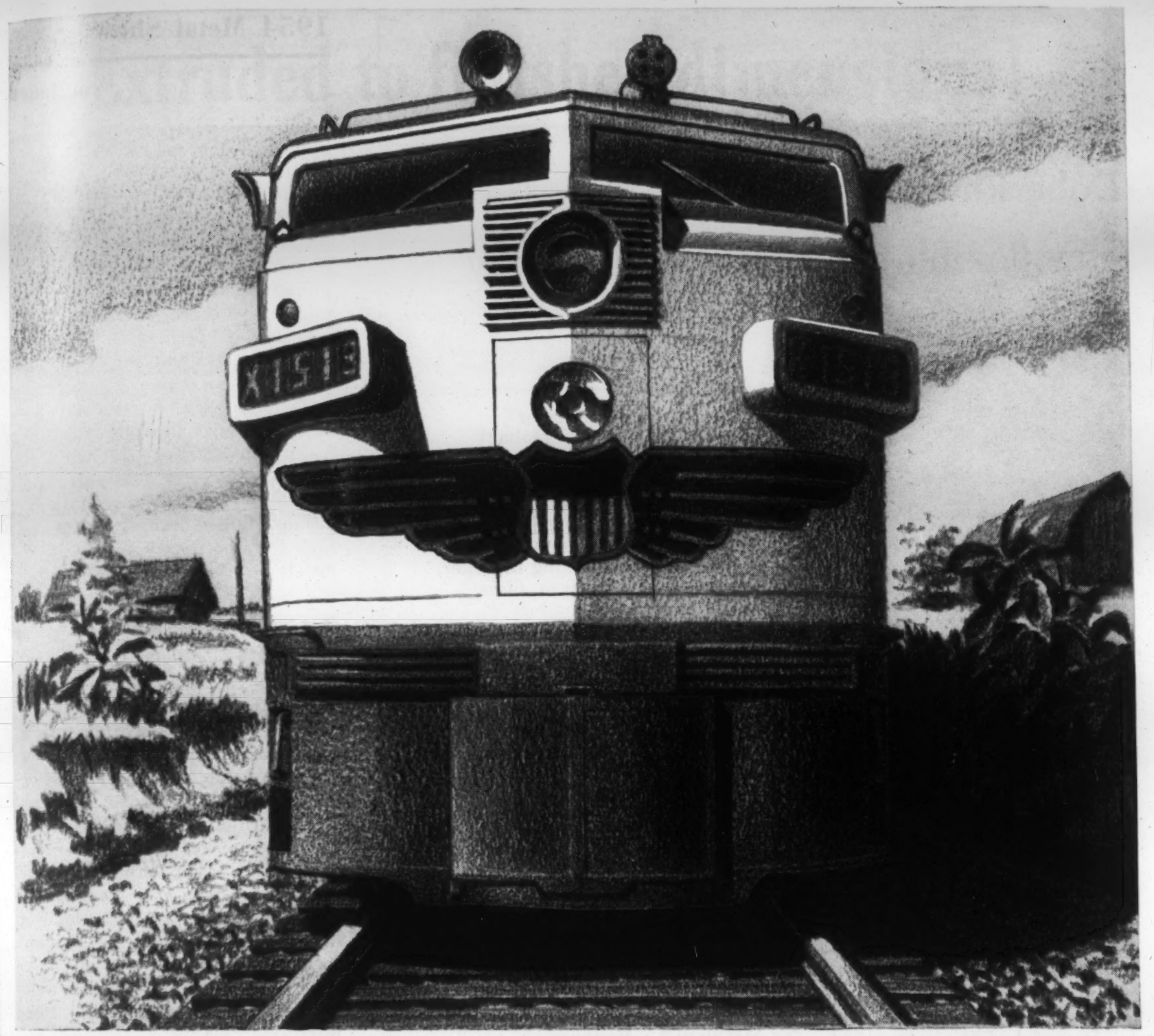
For more information, Circle No. 366



Here's where heat and corrosion prove metal...and metallurgists

For castings subject to High Fluctuating Temperatures . . .

Waukesha No. 321 Titanium Stabilized Stainless Steel

Supercharger inlet ports in giant railroad diesels demand castings of unusual characteristics. They must be high in corrosion resistance, and must maintain this resistance under abnormally high temperature fluctuations. In addition, close tolerances demand easy machinability.

This is the kind of problem that naturally comes to Waukesha Metallurgists for laboratory solution. Waukesha No. 321 Stainless Steel with *titanium,* with carefully controlled modifications, offered a solution. Its effective use in castings requires a high degree of knowledge and skill both in formulation and in production, but Waukesha has succeeded in casting it for such critical uses as trays and conveyor parts for heat treating furnaces and other high temperature needs. Its adaption to G-E Supercharger inlet ports is another example of Waukesha's experience in serving industry with the more difficult alloys.

Have You a Castings Problem?

Take this opportunity to prove Waukesha's advanced metallurgical service — to your profit! Send us a pattern for sample casting. Or write for booklets containing current data on Waukesha Stainless Steel and "Waukesha Metal".

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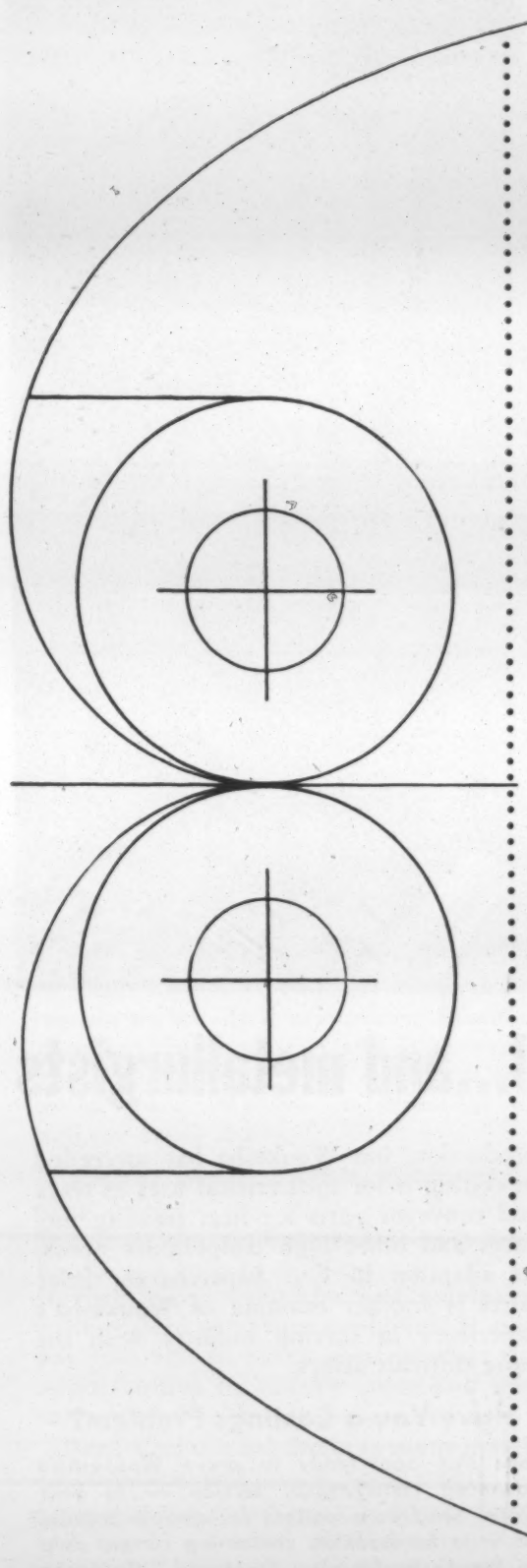

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1954 Metal Show

continued

tivities of the society on Thursday night.

The ASM will also conduct a special session of the Committee on Metallurgical education, at which prominent educators will discuss a projected laboratory manual for teaching process metallurgy. The Meeting will be held on Monday at 9:30 a.m. and will permit audience discussion.

Technical sessions at the Palmer House Monday through Friday will cover constitutional diagrams, mechanical metallurgy, processing, hardenability, ferrous physical metallurgy, stainless steels, heat treatment, and high temperature properties of metals.

American Welding Society

The National Fall Meeting of the American Welding Society will feature reports on the latest advances in welding and its uses. Fifty-seven papers will cover all phases of welding activity at the nineteen sessions in the Sherman Hotel.

Fifteen hundred AWS members are expected to attend. They will hear papers by top authorities on the welding of titanium, zirconium and molybdenum, the use of welding in the production of aircraft and rockets, welding high temperature materials, inert-gas-shielded arc welding, resistance welding, and fused metallized coatings.

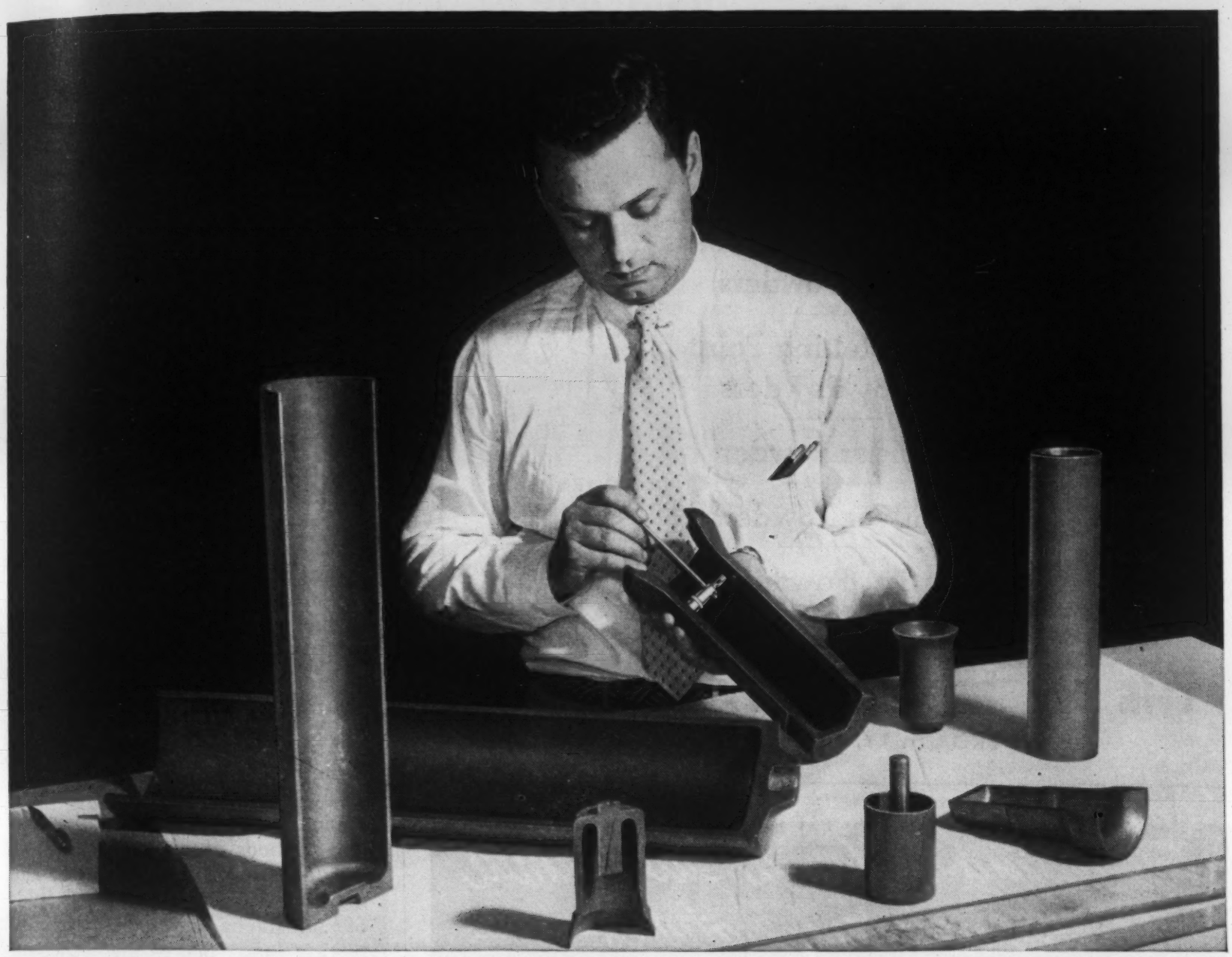
Other papers will cover the relatively new "contact" type of electrodes, latest methods of hard surfacing, new developments in arc and oxygen cutting of metals, and recent advances in copper and silver brazing.

There will also be sessions on welding pressure vessels and piping, weldability, structural welding, flame descaling, and welding in design and production.

A highlight of the technical sessions will be the Adams Lecture on Monday morning, to be presented by William L. Warner of Watertown Arsenal. His subject will be *The Toughness of Weldability*. At this honors session a number of other prize awards will be presented to individuals for outstanding contributions to the advance of welding. On Monday evening, the annual President's Reception and National Dinner will be held.

(Continued on page 258)

Extruded to finished dimensions!



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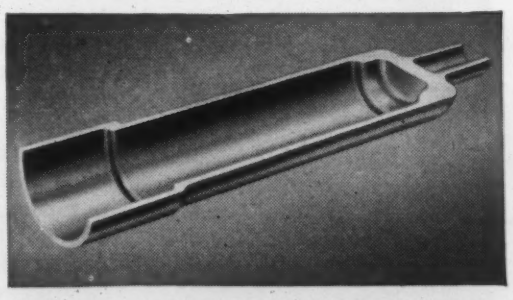
Let us quote on *your* parts . . . simply give us design details and specifications, and your quantity requirements.

Write or call the nearest Mullins office for engineering information. For copy of new booklet "How would you tool-up to make an egg?", write Koldflo Division, Mullins Manufacturing Corporation, Salem, Ohio.



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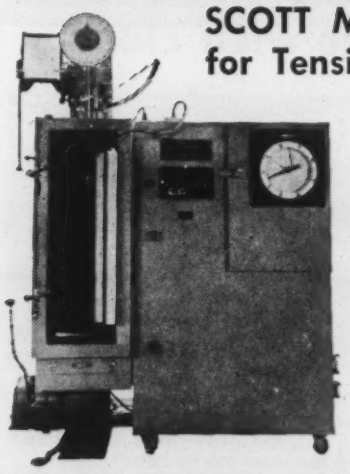

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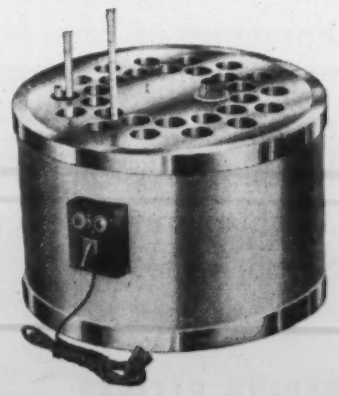
Scott Model L-8 incorporates a self-contained conditioning unit with electric heaters, a circulating fan, Brown temperature recorder, control panel for manual operation, refrigeration coils suitable for dry ice cooling which when coupled with the electric heaters and automatic controls allow for temperature variations from minus 70° to plus 300° F. If you require elevated temperatures only, in the range up to 300° F, we have available a conditioning cabinet which can be attached to a standard Scott Tester eliminating the need for getting a special model.

SCOTT TESTER* MODEL LG
for Temperature Ageing Tests to 450° F.

This solid aluminum block oven is available in standard models for both oven ageing studies and oxygen ageing studies of rubber, silicones and other elastomeric materials. For oven ageing it is built with 28 individual compartments 1½" in diameter. For oxygen ageing the compartments are larger, and fewer in number. Completely equipped as a plug-in unit, with built-in heating elements and temperature controls.



Complete information upon request.

SCOTT TESTERS, INC.
*REGISTERED TRADEMARK

65 Blackstone St.,
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For more information. turn to Reader Service Card, Circle No. 501

1954 Metal Show

continued

Institute of Metals Division, AIME

The IMD will hold technical sessions at the Morrison Hotel, morning, afternoon and evening, Monday through Wednesday. The expected highlight of the sessions will be the Third Annual Titanium Symposium scheduled for all day Tuesday. Technical papers will cover commercial alloys, melting, heat treatment and joining. Tuesday afternoon's session will feature a round table discussion of tianium by representative experts from major industries. The annual IMD Fall Dinner will take place Tuesday night. Other technical sessions will include a number of papers on deformation, constitution, diffusion, powder metallurgy, phase transformation and recrystallization, metal science, and creep.

Society for Nondestructive Testing

The Society for Nondestructive Testing will open its technical program with a full day of educational sessions generally covering all aspects and methods of nondestructive testing. Subsequent sessions will go into more detail in the specialized fields of radiography, ultrasonics, magnetic particle and fluorescent penetrant techniques of inspection. The morning session on Thursday will cover nondestructive testing as applied to airlines, railways, oil, and shipbuilding. The annual meeting and honors lecture, to be delivered by Dr. E. E. Charlton, takes place Wednesday afternoon.

Special Libraries Association

The Metals Division of the Special Libraries Association will sponsor two technical sessions on Thursday, Nov. 4, and two field trips, to the John Crear Library and the Purdue Extension Library.

Industrial Heating Equipment Association

Under the auspices of the ASM, the Industrial Heat Treating Equipment Association will present three panel sessions on furnace atmospheres and induction heating. The discussions will cover atmospheric gases, control and safety in connection with these gases, and induction heating.

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How Tempilstiks° are used

● TEMPILSTIKS° are temperature-sensitive crayons of calibrated melting points. There are some sixty-five different TEMPILSTIKS° in the range from 113°F to 2000°F, each indicating a specified temperature, within a tolerance of plus or minus 1% of its rating.

The appropriate TEMPILSTIK° is selected and, for most applications, the work-piece is marked with it before heat is applied. On subsequent heating the crayon-like mark of the TEMPILSTIK° melts as soon as its temperature rating is reached.

The mark made by a TEMPILSTIK° may gradually change in color as heating progresses. The change in color, or in color intensity, is never to be interpreted as a temperature indication. The TEMPILSTIK° mark melts when its temperature rating is reached and only this change from the dry to the liquid condition is the significant temperature signal.

In some applications this simple method may not suffice because evaporation of the TEMPILSTIK° mark on prolonged heating, or its gradual absorption by the surface at high temperatures, may leave too little residual substance for unambiguous observation. In such cases stroking or touching the work-piece with the TEMPILSTIK° at regular intervals during the heating process is recommended. The TEMPILSTIK° will leave a dry mark at temperatures below its rating and a liquid streak when its temperature rating has been reached or exceeded. If the workpiece is not accessible for applying a TEMPILSTIK° during the heating process, then TEMPILAQ°, or possibly TEMPIL° PELLETS, should be used instead.

TEMPILSTIKS° will usually glide over unheated polished surfaces (like glass, polished stainless steel, etc.) without leaving an appreciable mark. Therefore, in applications that involve smooth or polished surfaces TEMPILSTIKS° should be used by touching or stroking the workpiece periodically during the heating process, as previously described, because a liquid streak will be made on contact as soon as the specified temperature is reached. Where it is necessary to mark a smooth work piece surface prior to heating, TEMPILAQ° should be used.

A hot radiating surface will appear relatively dark under intense illumination from an external source, and this fact can be utilized to improve recognition of the temperature signal against a red-hot background. The use of TEMPIL° PELLETS or TEMPILAQ° instead of TEMPILSTIKS° will further improve visibility under these conditions.

On rapidly moving objects, like magnesium or aluminum sheet during spinning operations, it is impossible to see whether the applied TEMPILSTIK° leaves a dry or melted mark. However, with a little experience operators quickly learn to sense the smooth gliding of a TEMPILSTIK° over a surface which is hot enough to melt it on contact, as contrasted to the frictional drag on a cooler surface. If the top of the TEMPILSTIK° is brought in contact with the moving metal surface for a brief moment at a time, and with light pressure only, the heat contribution of friction is trivial enough to be ignored.

The above described "sensing technique" may also be employed on hot radiating surfaces where the bright background makes it difficult to distinguish whether or not the TEMPILSTIK° mark had melted.

An appropriate series of TEMPILSTIK° marks, applied to the workpiece or surface under investigation before heating begins, will provide a record of the maximum temperature attained during a process or operation. Subsequent examination will show that all TEMPILSTIK° marks up to a certain temperature rating had melted, while those of a higher rating had not. The maximum attained temperature must consequently lie somewhere in the interval between the highest melted and the lowest unmelted TEMPILSTIK° rating.

The temperature distribution and isothermal boundaries of surfaces such as furnace walls, melting ladles, cement kilns, etc., can be established by using an appropriately chosen series of TEMPILSTIKS° to draw a pattern of lines (parallel, concentric, radial, etc.) on the area under investigation. The heat conduction along a surface can be effectively studied by the progressive melting of suitably chosen TEMPILSTIK° lines. Caution must be exercised not to permit the mark made with one TEMPILSTIK° rating to cross or overlap the mark of a dissimilar TEMPILSTIK°, as such a mixing of different TEMPILSTIK° marks would destroy their accuracy.

TEMPIL° products will give good results in induction heating and in ionized air, as well as in the presence of static electricity about electrical equipment, where electrical means of measuring temperatures often function erratically.

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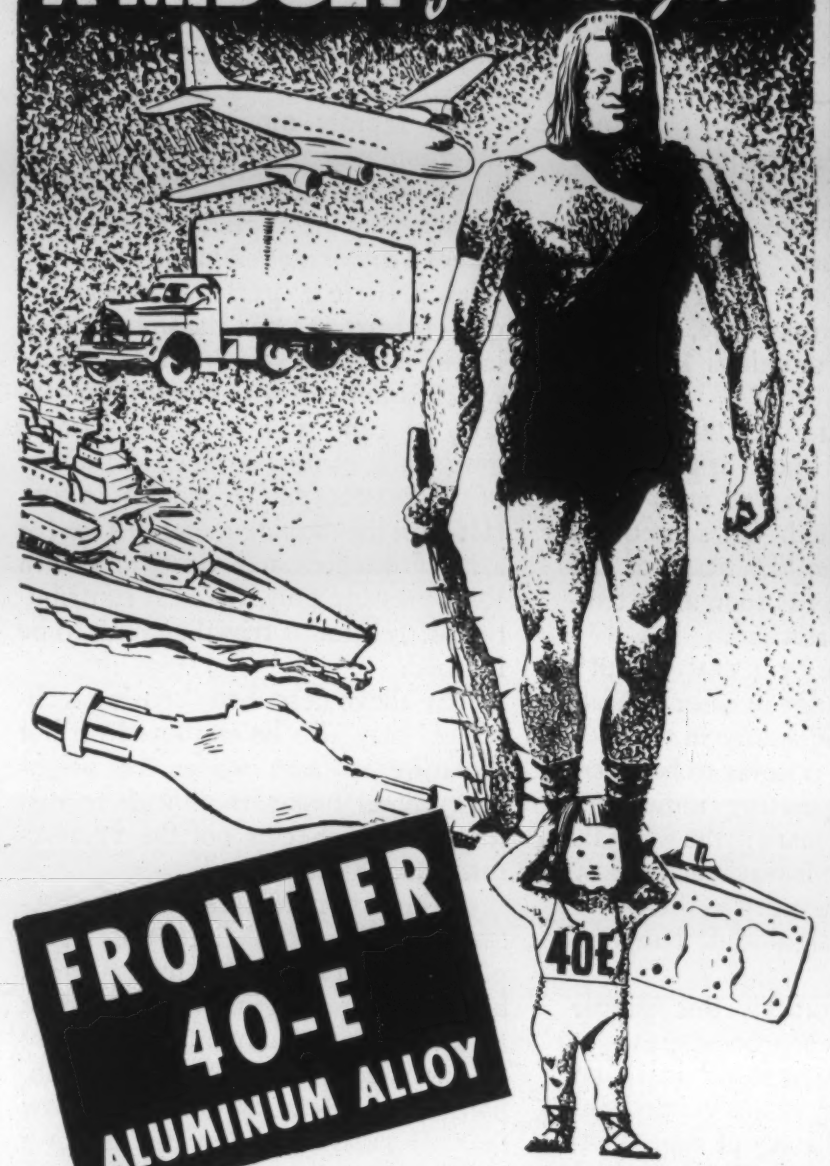

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